COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

February, 1946

Water flow inside drum of La Mont Boiler; see page 45

Steam Plant Serving New Refinery in Saudi Arabia ▶

La Mont Boilers in Great Britain ▶

Power in 1946 ▶

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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Editorial

Data Needed on Steam-Generating Equipment

The Census of Manufacturers, ordinarily compiled and published biennially, has not been taken since 1939 because of the war conditions in the intervening period. However, the Director of the Census, conscious of the changes in plant facilities incurred by the four years of war production and of the importance of obtaining early current statistics as an aid to business, has set in motion plans for carrying out such a survey during 1946. Preparatory to this work he has requested suggestions from various trade associations and the technical press, with a view to making the Census of Manufacturers of greater aid to industry than in the past.

The monthly reports covering output in various selected lines will continue to serve a useful purpose in indicating current trends, but statistics on capital goods already installed provide a key to potential markets when properly interpreted.

It will be recalled that in the past the Census of Manufacturers has contained data on electric power, in terms of installed motor and engine horsepower, as well as purchased power, in the various industries, arranged geographically; but has failed to record steam producing capacity. However, practically all process industries use large quantities of steam aside from that employed for the production of power. Many produce steam for process and heating while purchasing their electric power. The fuel used for such steam generation probably greatly exceeds that employed by central stations for the generation of electricity.

Such statistics, covering installed steam generating capacity, would be of inestimable value not only to manufacturers of boilers and fuel-burning equipment but also to manufacturers of feed pumps, coal-and-ash-handling equipment, fans, valves, gages, combustion controls and other appurtenances that go to make up the boiler plant. A large number of requests for the inclusion of statistics on installed steam-generating capacity, if received from such sources, would serve to convince the Director of the Census as to its importance and likely result in favorable action, especially in view of his expressed desire to make the forthcoming census most helpful.

That there is need for such data has been amply shown by the many inquiries over the years that have been addressed to the business press, but which the latter has been unable to answer owing to lack of information. While much of this information is existent, it is scattered among the records of state and municipal inspection departments, as well as in the files of individual boiler insurance companies, and has never been assembled; but the Government, through its organization for the forthcoming Census of Manufacturers is in a favorable position to collect these steam generating statistics.

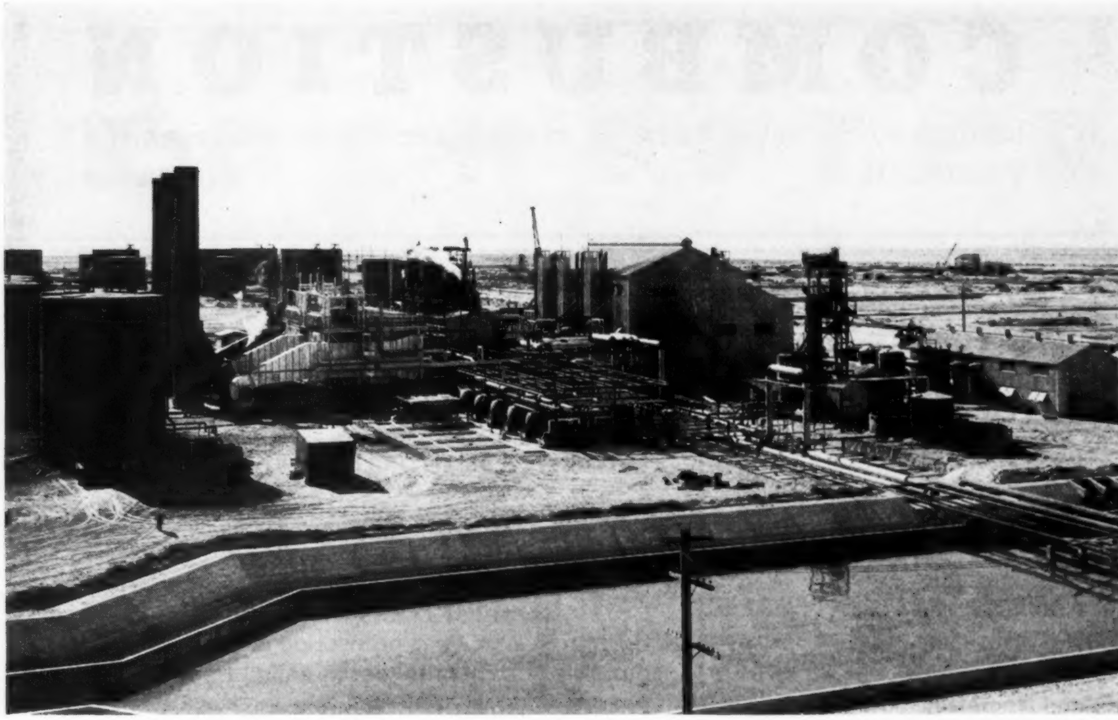

Fig. 1—Construction view of power plant area as of October 10, 1945

Steam Plant Serving New Refinery in Saudi Arabia

This installation which serves the refinery with electric power, process steam and various other services, is of semi-outdoor construction with special features to meet the prevailing climate. It contains three 220,000-lb-per-hr gas-fired steam-generating units and three 6000-kw turbine-generators, two of the mixed-pressure type and the third a back-pressure machine. Initial steam conditions are 625 psi, 750 F and arrangement of the equipment is especially adapted to refinery requirements.

In view of the important part played by oil in winning the war and the attention that is being given to future oil supplies in various parts of the world, particularly the Middle East, the steam plant now nearing completion for the Arabian-American Oil Company's new refinery at Ras Tanura, Saudi Arabia, is of special interest; more so perhaps since it was designed by American engineers and all of the equipment is of American manufacture.

This steam plant, designed to serve a refinery of 50,000 bbl per day initial capacity with electric power, process steam and various other facilities, also includes an extensive water-treating system for makeup to evaporators. It is of semi-outdoor construction with the turbines, their auxiliaries and the electrical bay housed; but with the boilers, fans, feedwater heaters, evaporators and water-treating system in the open. The boiler control room is enclosed and because of the prevailing high temperature special construction was employed.

The structure housing the turbines and electric control equipment is of steel frame with corrugated asbestos siding and roofing, and the operating floor is of grating to permit air circulation. The boiler control room, located

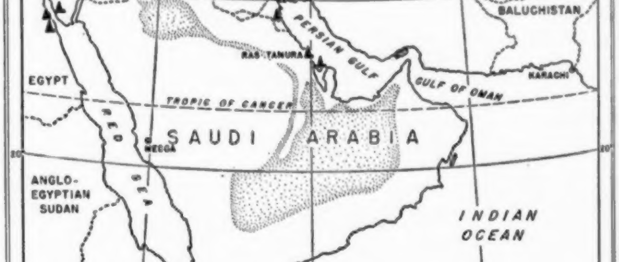

Fig. 2—Map of Saudi Arabia Showing location of refinery at Ras Tanura

above the pump bay, also has its walls and roof of corrugated asbestos with flat sheet asbestos on the inside. Walls and ceilings are insulated and the floor slab topped by several inches of insulating concrete under a granolithic finish. It is anticipated that this room will be air-conditioned when equipment for that purpose becomes available. A sunshade type of roof is provided for protection of operators in those portions of the pump bay that extend beyond the control house.

A special feature is a 50-ft wide pipe-way, depressed 3 ft below the level of the area and traversing the center of the plant. This contains the steam and water piping as well as the supply services to and from the refinery. This is shown in the general layout, Fig. 4.

Designed to meet an estimated normal electrical load of about 9000 kw, with possible increase to 12,500 kw, and process steam requirements of 200,000 to 300,000 lb per hr, in addition to compressed air and other services, the plant contains three 220,000-lb per hr steam-generating units and three 6000-kw turbine-generators. It is expected that two boilers and two turbine-generators will ordinarily carry the load, with the third boiler and turbine serving as spare capacity. The layout is flexible in this respect. Two of the turbines are mixed-pressure condensing, with high-pressure extraction and low-pressure admission and the third is a back-pressure unit exhausting to process at 150 psi. Initial steam conditions are 600 psig, 750 F total temperature at the throttle.

The primary fuel is refinery gas, with oil as an alternate fuel, should supply of the former be inadequate or interrupted.

Makeup water to the plant is taken from wells and, after passing through two-stage sodium-zeolite softeners and CO_2 removal equipment, is fed to the evaporators, vapor from which is discharged to the 150-psig process-steam header. Since only a portion of the process steam to the refinery is returned as condensate this arrangement results in an excellent quality of feedwater to the boilers. The high-pressure evaporator coil steam is extracted from the turbine at 225 psig, the low-pressure evaporator at 15 psig, and the condensate is returned to the boiler feed system.

Compressed air is furnished for general service at 125 psig by three 660-cfm motor-driven compressors, and for instrument and control service at 40 psig by two 310-cfm motor-driven compressors.

All auxiliaries are motor-driven with the exception of the three boiler feed pumps, three duplex fan units, two of the three condensate supply pumps which have dual drive, one of the fuel-oil pumps and one instrument air compressor which is dual driven.

Steam-Generating Units

The three main steam-generating units are of the two-drum Combustion Engineering type, each designed for a maximum output of 220,000 lb of steam per hour at 625 psig and 750 F at the superheater outlet when supplied with 360 F feedwater. The superheater is of the Elesco interbank arrangement and the furnace is completely water cooled with plain tubes backed by refractory and a weather-resistant setting. Because of the availability of the fuel no economizer or air preheater is employed.

Each furnace has four Peabody combination gas and oil burners and is designed for a heat release of 33,100 Btu per cu ft at maximum output when burning refinery gas of 22,100 Btu per lb. At this rating the calculated efficiency was 77.1 per cent.

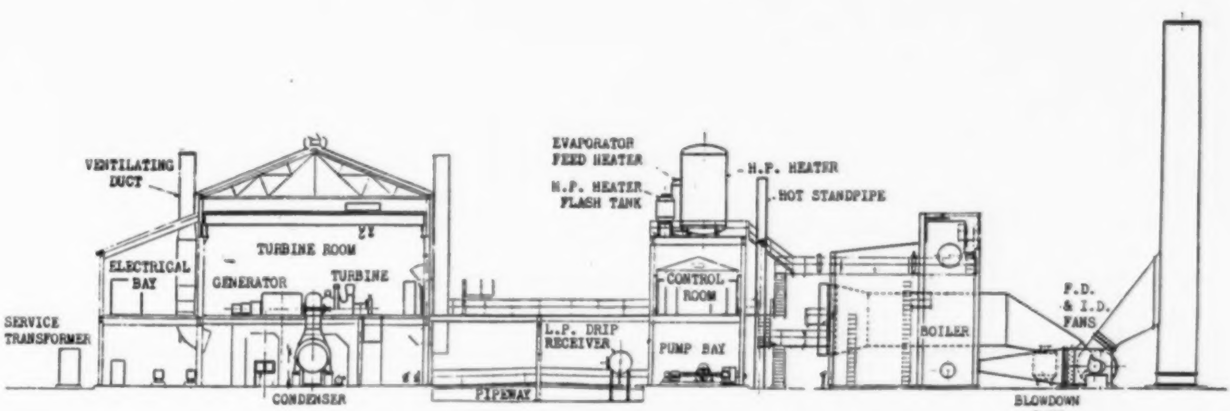

Fig. 3—Cross-section through power plant

Main Turbine-Generators

These are each rated at 6000-kw, 80 per cent power factor, and are capable of delivering 7500-kw at unity power factor. They are 3600-rpm, 60-cycle General Electric machines generating at 13,800 volts.

The two condensing turbines are arranged for high-pressure extraction and low-pressure admission. Steam may be drawn from the high-pressure extraction points to the extent of 200,000 lb per hr at 150 psig or 184,000 lb per hr at 225 psig, or steam may be introduced to the extent of 75,000 lb per hr at 12 psig. Initial steam conditions are 600 psig and 750 F at the throttle. Control valves, forming an integral part of the turbine, serve to maintain the high-pressure extraction pressure and the low-pressure admission pressure. That is, the former may be set to maintain 150 psig on the refinery process supply header or to maintain 225 psig on the evaporator coil supply system. The admission control serves to maintain the pressure in the exhaust header at approximately 15 psig.

The 6000-kw back-pressure machine is intended to exhaust to process at 150 psig but may exhaust to the 225-psig system under which condition it will develop only 5100 kw.

In the normal operation of the turbines it was intended that the non-condensing unit would be controlled by the back-pressure governor to maintain approximately 150 psig on the main process steam header to the refinery. One of the condensing turbines would operate to maintain frequency on the electrical system by assuming the balance of the load not taken by the back-pressure turbine. This condensing machine would also supply steam from the high-pressure extraction point to maintain 225 psig on the header supplying the evaporator coils and would absorb steam from the exhaust header to maintain a pressure of 15 psi in that system.

In the event that the back-pressure turbine is out of service, the second condensing turbine can be operated rectly into the reduced pressure line, as the desuperheating medium.

Fans

Each boiler is served by a Sturtevant forced-draft fan and an induced-draft fan of the same make, arranged with a common drive turbine which is connected through reduction gearing to the induced-draft fan. The forced-draft fan is driven from the induced-draft fan by means of an extended shaft with floating couplings (see Figs. 4 and 6). This arrangement permitted the forced- and induced-draft ducts to be designed without offsets, thus giving minimum draft loss. The three fan turbines, of Terry design, develop 400 hp each when operating at 4500

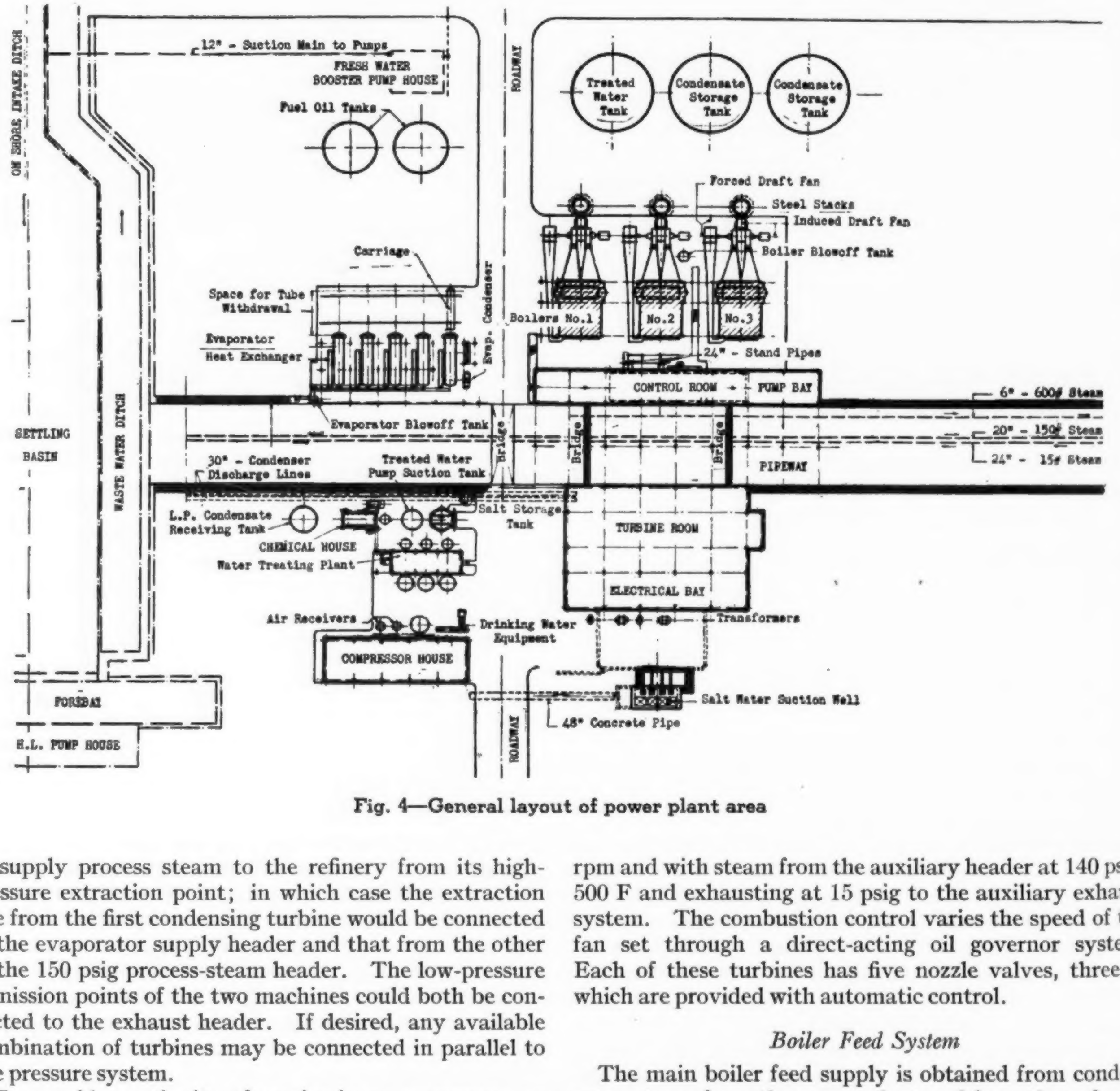

Fig. 4—General layout of power plant area

to supply process steam to the refinery from its high-pressure extraction point; in which case the extraction line from the first condensing turbine would be connected to the evaporator supply header and that from the other to the 150 psig process-steam header. The low-pressure admission points of the two machines could both be connected to the exhaust header. If desired, any available combination of turbines may be connected in parallel to one pressure system.

To provide continuity of service in an emergency, or unusual turbine outage, or in starting up after a complete shutdown, reducing valve ties are installed between the 600- and 150-psi steam headers; also between the 225- and 150-psi headers, and between the 150- and 15-psi headers. In order to prevent excessive steam temperature under such conditions desuperheating stations are provided, employing boiler feedwater introduced di-

rpm and with steam from the auxiliary header at 140 psig, 500 F and exhausting at 15 psig to the auxiliary exhaust system. The combustion control varies the speed of the fan set through a direct-acting oil governor system. Each of these turbines has five nozzle valves, three of which are provided with automatic control.

Boiler Feed System

The main boiler feed supply is obtained from condensate returns from the power plant and from the refinery, which are passed through a deaerating heater operated from the 15-psi exhaust header and then through a high-pressure direct-contact heater operated from the 150-psi header.

For handling this each boiler is served by a pump unit consisting of a primary and a secondary centrifugal pump of Ingersoll-Rand design, arranged in tandem with a

common turbine drive. The primary pump has a capacity of 540 gpm and the secondary pump a capacity of 650 gpm, the difference being that the former handles water from the deaerator; and the latter, water from the high-pressure heater (see flow diagram, Fig. 5). The governing system of the driving turbine is arranged so that a constant pressure will be maintained in the secondary pump discharge header by speed control of the unit. A speed variation not exceeding 10 per cent was deemed sufficient for maintaining a header pressure of 745 psig at all boiler loads. Both the primary and the secondary pumps have corrosion-resistant trim to meet the condition of relatively pure condensate and elevated temperature.

Condensate from the condensing turbines and from the refinery returns is collected and supplied to the deaerating heater by three single-stage pumps of 510 gpm each at 122 ft total dynamic head. Normally, the two dual-drive pumps will be driven by the motor, but if for any reason the motor stops, a steam-valve solenoid valve will start the turbine.

Treated makeup is supplied to the evaporator system by three motor-driven pumps which are practically duplicates of the condensate-supply pumps and take their suction from a 10,000-gal storage tank.

The system contains numerous other pumps which will be apparent by reference to the flow diagram.

Condensers and Circulating Water Pumps

Each condensing turbine exhausts to a 8528-sq ft Worthington surface condenser equipped with automatic recirculation control. This control is designed to maintain a constant differential temperature of 15 deg F across the ejector condenser. During light loads insufficient flow of condensate through the inter- and after-condenser causes the temperature rise of the condensate to increase, thereby opening the control valve in the recirculating line and returning a portion of the hot condensate to the condenser shell where it is cooled and recirculated. At the same time the control valve in the condensate discharge line, under action of the hotwell-level controller, opens sufficiently to permit disposal of the condensate at the rate of forming in the condenser.

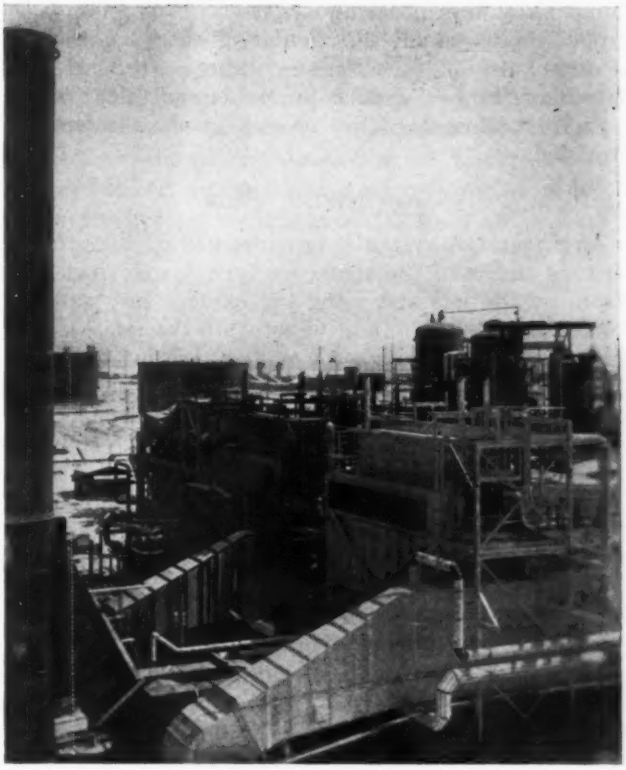

Fig. 6—Close-up view of boiler plant showing fan arrangement in foreground

Circulating water for the condensers is handled by four motor-driven Pomona vertical pumps, two having a rated capacity of 7500 gpm at 32 ft total dynamic head and the other two a capacity of 3750 gpm each. These

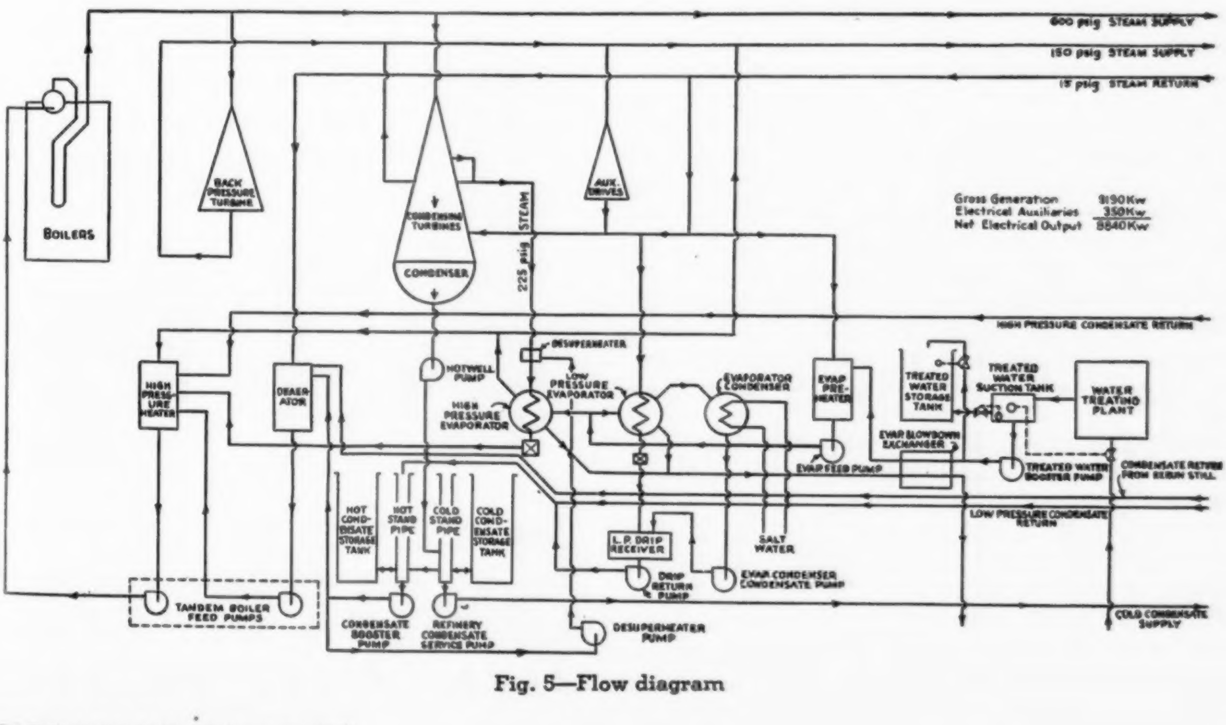

Fig. 5—Flow diagram

pump sizes were chosen so that each large pump can supply approximately the circulating water requirements of one of the main condensers; whereas the combined output of the two smaller pumps is equivalent to this capacity. Thus flexibility as well as spare capacity is provided.

Refrigeration Plant

A refrigeration system is provided having a capacity of 50 tons and is of the steam-jet type, employing 15-psi steam on the jets and using the refinery salt water for condensing the steam and vapor from the jets. Chilled water circulates through the system, leaving the refrigerating unit at 50 F and returning about 12 deg warmer. This water is distributed throughout the refinery for drinking purposes and for air conditioning. It is also employed in an instrument air subcooler where it serves to chill the air sufficiently to remove objectionable quantities of moisture. Makeup to the chilled water system is taken from a 10,000-gallon distilled water storage tank. The condensate from the refrigerating unit condenser is pumped to the hot condensate standpipe in the power plant.

Three 660-cfm, two-stage, motor-driven compressors provide 125-psi service air for maintenance purposes throughout the refinery. These units are equipped with inter- and after-coolers employing salt water from the refinery system as the cooling medium. There are also two 310-cfm, single-stage, motor-driven compressors with after-coolers providing 35- to 40-psi air for operation of controls and instruments. All the compressors are housed in a building located northwest of the turbine room.

Electrical Features

Power is generated at 13,800 volts, 3-phase, 60 cycles and is distributed from metal-clad switchgear containing nine circuits—three for the generators, four for feeders, and two for station service. The four 13,800-volt outgoing feeders consist of three-conductor, 500,000 cir mil paper-lead-covered cables carried in underground ducts to two outside switching centers, from which refinery feeders distribute at 13,800 volts. Station auxiliaries are supplied, through a step-down transformer, at 480 volts.

A 60-cell, 125-volt storage battery and a 5-kw battery-charging motor-generator set are provided for circuit-breaker control circuits and emergency lights. Also, two 90-kw, 2300-volt diesel-driven generators are installed to provide power for starting a cold plant and to provide lighting and a limited amount of power in the event of a complete shutdown of the turbine-generators. These diesel sets are connected to the station auxiliary bus through a 200-kva, 2400/480-volt 3-phase transformer; they were originally purchased for construction purposes.

Lighting of the power plant and the surrounding area is supplied at 208/120 volts, four-wire from a transformer connected to the 480-volt station feeder.

The power plant was designed by Stone & Webster Engineering Corporation, Boston, acting as consulting engineers, to whom we are indebted for information contained in this article. We also are indebted to J. C. Stirton, of the Arabian-American Oil Company for approval and permission to publish it.

POWER IN 1946

By A. G. CHRISTIE

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The January issue contained a brief staff review of progress in steam engineering over the past year. While that issue was on the press the following contribution was received from Professor Christie. While this reiterates some of the points mentioned in the January review, it extends further to the broader field of power generation. For this reason and because it reflects the individual views of a well-known authority in the field, space is being given to its publication—Editor

THE year 1946 should be one in which much planning and development will be done in the engineering of power plants. Strike difficulties must be cleared up shortly for this country cannot afford to allow lengthy bickering between capital and labor. An enormous demand for domestic goods and machinery exists. This demand may well tax the capacities of our central station systems where only absolutely necessary additions were permitted during the war years and where in many cases reserves were reduced to a minimum. Moreover, industrial and private plants have experienced five years of extraordinarily hard usage. Depreciation has been accelerated and replacements in many cases are necessary. Finally, new methods of converting energy appeared during the later war years that may possibly alter earlier practices in power generation. With these considerations in mind, it is timely to review the state of the art of power generation.

Atomic Energy

Popular attention has been centered on atomic energy and its possibilities as a result of the use of the atomic bomb against Japan. Much has been published concerning uranium 235 and its potential applications. Few authoritative statements have appeared from those who participated in the developments of this source of energy. There are still little factual data available regarding the cost of plant to produce the necessary materials that would be capable of releasing atomic energy, nor of the quantities of electrical energy required to break down the original uranium 238 in the atom-smashing machines where the active elements are produced. There is a probability that this may be kept secret for a time for international reasons. However, work is already proceeding in various laboratories on the useful applications of atomic energy and its by-products.

Large quantities of heat are available from the liberation of atomic energy and this may be usefully employed. A more fertile field of effort for scientists would be the search for a method by which this atomic energy could be converted directly into electrical energy that would be distributed directly over our present electrical systems; or possibly it might be converted into radio-electric energy and means discovered to transmit power through space by radio.

Engineers appear to be on the threshold of a whole new world of "applied energy." In years to follow much study and thought will have to be devoted to these rapidly developing concepts if a power engineer is to keep up to date in his chosen profession. For the moment, the engineer may dismiss the thought of immediate use of atomic energy as a source of power in pending developments until the enforced secrecy is lifted.

When considering energy conversions, there is another field which has intriguing possibilities. Heat waves and radio waves differ in wave length. While physicists at present know of no method by which one wave length may be converted directly into another, it is not beyond imagination that such a process ultimately may be discovered. Should such be found the engineer would only need to burn coal or other fuel in a furnace from which electrical energy would be taken directly and at high efficiency.

Steam Central Stations

It is a reasonable assumption that engineers during the current year will be concerned principally with refinements and extensions of steam power stations. With war restrictions lifted, new developments in the art of power station design and operation may appear. The following paragraphs suggest possible trends in these developments but the omission of certain ideas does not in any way reflect on the value or effectiveness of these schemes.

The out-door power plant has demonstrated its suitability in certain locations. The omission of enclosing walls, roof, etc., has lowered the initial plant cost. Engineers must analyze each projected new plant to determine whether the out-door plant is practicable in view of seasonal conditions and whether the savings in plant cost offset possible delays in construction, maintenance and overhaul due to inclement weather, dust conditions and lack of accessibility.

There has been no outstanding new development in coal-handling methods. Local conditions generally govern the selection of equipment. Belt conveyors seem to be the favored transport system. Recurring strikes and strike threats justify extensive coal storage. Hydraulic methods of ash removal have eliminated much of the hard labor and dusty conditions common in older plants.

The combustion of coal will present increasing problems. Ash contents will increase due to lack of labor at mines for pickers, to the more extended use of mechanical loaders in the mines which do not separate bone from coal, and to strip-mined coal which is in general dirtier because of the unavoidable admixture of portions of the overburden. This ash content lowers the heating value, increases freight charges, adds to pulverizing costs and requires the handling of greater amounts of ash and refuse. Since more ash substance enters the furnace, slagging conditions may be aggravated and may vary as

the nature of the ash changes. Flue-dust collectors may be overloaded by excess ash.

Standard types of coal pulverizers appear to have reached a more or less static stage of development. However, the flash pulverization process with air now under test at Johns Hopkins University offers some intriguing possibilities. More information regarding this process will be available shortly.

Among stokers, the spreader type appears to enjoy increasing popularity due to its versatility with different types of coal and to the efficiencies that can be obtained under average conditions. Traveling grates to remove ash from spreader stokers are increasing in use.

A problem with both pulverized coal and spreader stokers is the disposal of cinders caught in the passes of the boiler or in the cinder catchers in the path of the flue gases. These coke cinders are less reactive than coal and ignite less readily. Methods are under trial to project this ash and cinder into the furnace to be consumed or discharged in the normal manner.

The effectiveness of radiant energy as a means of transferring heat from burning fuel to boiler surface forms a dominant consideration in the design of new steam generators. Future designs, especially in the large sizes, are likely to embody radiant heat transfer to an increasing extent with only such convection surface as may be necessary to screen superheater tubes and provide necessary water circulation.

Difficulties have been experienced with wastage of the metal on the fire side of water-wall tubes. These appear to be related to the combustion process in which an insufficiency of air may exist at certain points in the furnace. This suggests the need of studies of gas flow conditions in furnaces by means of transparent models. Eddies, reverse flows and other irregular conditions may become apparent and means to correct these can be developed on the models.

Increased steam pressures have necessitated greater attention to the treatment of feedwater both outside of and in the boilers. Many methods—too numerous to discuss adequately in this article—are in use to meet the varying waters encountered and the different percentages of makeup. For a time there was keen rivalry between the lime-soda and the zeolite systems. Future systems will take advantage of the best elements of both methods and combine these with supplemental acid treatment to lessen total solids to the boiler. This combined system may lower the silica in the feedwater. In the boiler itself changes in treatment are under study with potassium salts in some cases replacing sodium as the alkaline element. Corrosion is still an important consideration. Acid cleaning of scale from boiler surfaces has been carried out in many plants.

The operation of forced-circulation boilers is followed with interest, and further improvements in design and operation may be expected. The advantages of this construction are the use of smaller tubes and thus less weight in the boiler, and positive circulation in the different tubes. However, the designers of natural-circulation boilers have developed types which have proved satisfactory in the highest pressure service now in use.

Superheaters in general are of the convection type or at most, semi-radiant, protected by a screen of convection tubes. The introduction of gas turbines in service at temperatures in excess of current steam practice will encourage engineers to increase steam temperatures. This will require new materials for the higher temperature sections of superheaters that will resist action of dissociation of the steam and the consequent oxidation of the metal of the tubes. The high-temperature section may be in the form of radiant heat absorbing furnace walls, with new techniques for deslagging such surfaces. Various methods of superheat control are still under observation.

The overall efficiency of a steam generating unit depends principally upon the degree to which the flue gases are cooled by the economizer and air heater, if both are used. The limit in any case is now fixed at about 250 F under light load conditions. This appears to be the upper limit of the dew point of the acids formed by the catalytic combustion of the sulfur compounds in the coal. Below this temperature condensation products not only attack air heater parts but cause deposits of ash and dust to build up in the passages and hinder the gas flow. A foreign design of air preheater incorporates a section of stainless steel in the air preheater that can be frequently washed and which permits a further lowering of flue gas temperatures.

Piping Layouts

Central station designers have learned by experience to give most careful consideration to the design of pipe lines. In many cases actual models of the plant are constructed of plastics to determine the best layout. Then the stresses and strains under actual operating conditions must be provided for to care for this expansion.

High-pressure piping, both steam and boiler feed, is now welded throughout. This eliminates troubles with bolts and gaskets under high temperatures.

Troubles have developed in certain high-pressure, high-temperature steam pipes from graphitization after a period of service. This has been given serious study and its causes appear to be due to certain chemical elements added to alloy pipe during the formation of the steel. This treatment can be corrected in new steels and future piping will in all probability be free from this difficulty.

Forced- and induced-draft fans are necessary auxiliaries in most modern boiler plants. The efficiencies of such fans are still relatively low as compared with that of axial flow fans used on gas turbines where efficiencies of 82 to 85 per cent are claimed and may probably be exceeded as experience accumulates. Since large motors are required by forced- and induced-draft fans, a considerable saving in auxiliary power would result from the use of fans of equal efficiency to those on gas turbines.

A prominent engineer has stated that after the war, the public in large cities will demand that the gases discharged from the chimneys of new plants shall be as nearly colorless as the entering air. This would require high efficiency eliminators to remove dust particles from the gases as well as smokeless furnace operation. Dust catchers of many types are in use with varying degrees of satisfaction under differing conditions. Large coke or ash particles are separated best by centrifugal or reversal action while very fine particles respond best to electrostatic influences. A combination of the two methods is effective in cleaning the gases. One suggestion is to incorporate the coarse cinder catcher in the boiler design with the electrostatic separator as now a separate element beyond the boiler.

Stack Heights

Chimney height is a problem in new plants. Airplane authorities desire short chimneys. High chimneys cannot be justified as draft producers with the low flue gas temperatures now common. On the other hand, the neighborhoods of power plants are becoming increasingly conscious of the nuisance of flue gases from chimneys. Observations in Great Britain have shown that the gas plume from a chimney diffuses rapidly when wind velocity is low and gases are relatively cool. This plume may reach ground level in a comparatively short distance from the chimney under certain conditions and the gases then become a definite nuisance. The difficulty may be lessened even when relatively short chimneys are used by increasing the velocity of the gases in the stack. It has been shown experimentally that the usual allowances for friction loss in chimneys are too high and that gas velocities can be at least doubled at discharge with little increase in induced-draft fan power. This leads to a reduction in chimney diameter and hence in cost of stack and footings. New chimneys with velocities of 50 to 60 ft per sec at discharge are now in satisfactory use. Common practice in older designs was 20 ft per sec.

Prime Movers and Auxiliaries

An outstanding accomplishment of the past year was the selection of "Preferred Standards for Large 3600-RPM Condensing Steam Turbine-Generators" by a joint committee of A.S.M.E. and A.I.E.E. This standardization of sizes should lead to refinements in the design and improvements in the efficiency of such units as well as to a reduction in first cost. One outcome of such standardization has been the preparation of tables of performance by one of the large manufacturers covering the several standard sizes under the specified steam conditions with various stages of extraction for feedwater heating. These tables will save much work in making performance estimates of new plants or projected additions.

Further large gains in turbine efficiency are not to be expected. However, studies of stream flow are now being made on turbine blades that may result in small improvements in efficiency of individual units. Nozzles are receiving similar study.

Past experience has indicated improvements in efficiency with increases of revolutions per minute and at the same time unit weight is considerably reduced. During the war turbine builders had extended experience in the building of high-speed geared marine turbines. These experiences may lead to the use of still higher speed geared units for electric generation in land service than are now in use.

British designers employ diffuser exhaust nozzles on many of their units in order to increase the vacuum at the last stage of the turbine. This arrangement has not been used in the United States, for in many cases the leaving velocity from the last row already exceeds desirable values. In other words, American practice tends to crowd the capacity of the casings more so than is common abroad.

Turbine designs are a compromise between constructions involving a large number of stages with high efficiency and fewer stages at less economy, though probably of greater reliability. Costs are also an element favoring the simpler design. However, increased coal costs may justify the purchase of more efficient units.

A difficulty still to be overcome is the deposition of solids on the blading from the carryover in the steam in high-pressure units. Such deposits not only reduce the flow area through the blades and lower the unit capacity but, if chlorides are present in these solids, corrosion of the blades may become serious. Such may occur from leaky condenser tubes where the circulating water is salty. The only apparent solution is the delivery of absolutely pure steam from the boiler.

No new ideas have developed in regard to the operating cycle of turbines. The "Preferred Standards," referred to above, fix the temperatures at the several points of extraction and thus will remove one of the variables formerly characteristic of station design. Heater designs and auxiliaries can now be standardized. Condenser designs may also become more standard.

Designers have frequently had difficulty in incorporating with the feed heating cycle an evaporator and evaporator condenser for necessary makeup. The development of the new Kleinschmidt evaporator widely used on shipboard should solve many design problems. This evaporator by employing re-compression of the distilled steam, requires only a small amount of cycle steam to maintain it at full capacity. Evaporator condensers are not needed with this construction, which will simplify heat balance layout.

Condenser designs show a greater appreciation of the optimum conditions desired in a condenser, namely, low pressure drop in the steam through the tube bank; maximum cooling of the noncondensable gases to the steam jet air pump; reheating of the condensate in the hotwell to exhaust steam temperatures; minimum pumping heads on the circulating water pumps through better design of the water boxes; and maintenance of clean condenser tubes on the water side. This latter condition is generally obtained by chlorination of the circulating water. A better knowledge of the conditions that lead to tube fouling now governs the amount of chlorine to be added at various times during the year.

Vertical circulating pumps of several designs have been used extensively in new stations. These save space and in many cases they are placed out of doors on docks or intake wells. Some designers now favor the use of cast-iron pressure pipes to and from the condensers in place of the deep intake and discharge tunnels formerly built into power plants. These intake tunnels necessarily had to be below water level; they were difficult and costly to build and, when built, often interfered with both the building and turbine-generator unit foundations. They were also troublesome if marine growths were prevalent as they had to be frequently dewatered and cleaned.

Diesel Engines

The diesel engine was widely used during the war and many men were given extensive training in its operation and maintenance. Standardization of designs may tend to reduce its hitherto high first cost. These circumstances will doubtless lead to further uses of this engine in the smaller central stations and municipal plants and in some industrial plants. It possesses the advantage of no standby losses, quick starting and high thermal efficiency. Its maintenance problems have to do with

lubrication, piston rings and valves. Supercharging will be used on many new units.

The Gas Turbine

The war greatly accelerated the development of the gas turbine and many firms are now busy on research work and new designs. Abroad there appears to be an equally intense interest in this new prime mover and units up to 12,000 kw have already been built. There seems little doubt that the gas turbine will find wide use in this country and will become a serious competitor of the diesel engine. It has the advantage of pure rotary motion. It needs practically no water unless intercoolers are used and in advanced designs, gives promise of thermal efficiencies equal to those of diesel engines. Problems connected with control under variable load conditions remain to be solved in certain types.

Intake air temperature has more influence upon the capacity of gas turbines than is generally realized. For instance, a unit under consideration for an American power station in the South will have a maximum capacity under summer conditions with 100 F ambient temperature of 10,000 kw. Under winter conditions with air temperatures of 50 F, the same unit could develop about 13,500 kw. This may have advantages in meeting winter peak loads.

Progress has been made in the application of the gas turbine to locomotives. A coal-fired gas turbine for locomotive use is now under intensive development.

Industrial Plants

Many power plants of industries will need early replacement. In general, these are in poorer shape than those of the utilities for additions are less modern and equipment has been heavily overloaded during the war period. It is also generally the case that both plant operators and labor are less skilled than in central stations. Industrial executives are prone to postpone expenditures for betterments in their power plants.

The needs of industry for space heating and also in many cases for process steam makes boiler plants necessary. When considering a new plant, a decision must be made whether to generate or purchase power. This is a local problem in each case and can only be settled by a careful study of the particular operating conditions, probable loads, and utility rates. In some cases where demands for power exist over the whole twenty-four hours, there is ample justification for the installation of boilers and generating equipment. Interconnection and interchange with the utility service may be profitable to both parties under these circumstances. On the other hand, industries that operate for such short periods as 40 hours per week may have such low annual load factors that the cost of a new power plant may not be justified, particularly where utility rates are reasonably low. The old boilers may continue to be used at low pressure, for space heating. In still other cases, diesel engines or gas turbines may be installed to furnish power with the older boiler plant serving heating loads. Some by-product heat may be recovered from diesel engines and gas turbines. Consideration has been given to the use of the exhaust of the gas turbine for drying purposes in an industry where much material requires drying.

In planning new industrial power plants thought should be given to possible air-conditioning loads in the future. Production can be increased in many industries by providing proper working conditions throughout the year. In winter this would require both heating and humidifying. In summer refrigeration and dehumidification may be necessary. Both services add to the demands on the power plant.

One cannot overlook the possibilities of the heat pump in connection with these services. Such a device would pump heat out in summer. The power requirements of the heat pump could be supplied by either diesel engines, gas turbines or utility service and a boiler plant would not be necessary.

When power is to be developed, the design of industrial power plants is following the best central station practice. Higher steam pressures and temperatures are being used. A common standard is 450 psia, 750 F although there seems no reason why 600 psia, 825 F should be overlooked. In fact, some plants have adopted such steam conditions, or higher. Boiler construction conforms to modern ideas and either economizers or air heaters, or both, are used. Most of these plants will have to install dust and smoke eliminators. Hence both forced- and induced-draft fans will be required.

Industrial plants are subject to wide variations in load—heavy day loads and frequently light loads at night. While pulverized coal is used in some plants, stokers are favored in other plants.

Coal and ash handling are frequently one of the main expenses of such plants. The increase in labor rates favors the development of comparatively simple coal- and ash-handling systems. A suggestion is the use of an unloading hopper from which a feeder and bucket conveyor elevates the coal to an overhead tank. A system of screw conveyors could distribute the coal to stoker hoppers. Low-cost ash-handling systems are difficult to work out in small plants. A modified water-sluicing system would be a desirable method but is not always economically justified.

When a new plant is under consideration, study should be given to the "package" type similar to that which has been supplied by several manufacturers to our Allies. The engineering and designs of these have already been completed and manufacturing costs should therefore be low.

Instrumentation

Labor costs are increasing. Experienced men are few. Hence it is necessary in all plants to use control and other instruments to a greater extent than heretofore to assure maximum operating efficiency.

Automatic controls of feedwater levels, air and coal supply to the furnace and forced- and induced-draft fans can assure satisfactory results. There will also be necessary such indicating instruments as will aid the operator in intelligent operation.

Electronic devices of many types were developed during the war. Many of these will find new applications in power plant service. As a result of these and other new discoveries, one may expect an array of instruments and controls from which to select the necessary units.

Engineers will have much to do in 1946. New developments may be expected and many new plants will be designed and built. Let us earnestly hope that full advantage will be taken in all these new plants of the latest developments in the art of power generation.

Large Steam-Generating Unit in Russian Steel Mill

NOW that the war is over and the veil of secrecy which prevailed with regard to wartime power installations has been lifted here and to a large extent abroad, it is possible to touch upon some of the more important jobs of that period. Of special interest are American-built steam-generating units supplied to Russia. The large number of power trains and package plants, shipped to that country during the past two years for emergency service in devastated areas, have already been described in engineering society papers and in the technical press; but these units were of relatively small capacity and little has been published concerning the large units furnished to rehabilitate basic industries. Typical is the steam-generating unit here described which was built for steel plant service and presumably is now in operation.

This unit, rated at 450,000 lb per hr evaporation on a 24-hr basis, at 477 psi and 787 F at the superheater outlet, is of the Combustion Engineering three-drum type with economizer and regenerative air preheater, the latter located at the operating level with the forced- and induced-draft fans in the basement. A bubble-type steam washer is fitted in the rear drum. Automatic combustion control is provided and superheat temperature is controlled through bypass dampers.

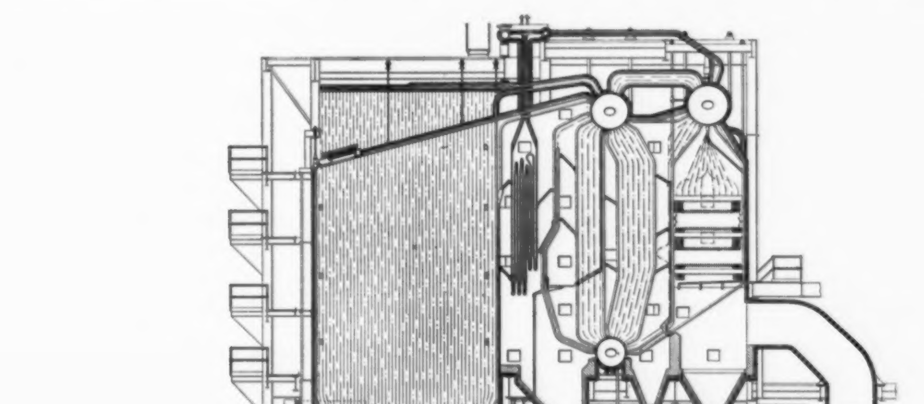
It is designed to burn lignite and blast-furnace gas, either separately or in combination; also coke-oven gas, of 450 Btu per cu ft, up to about 25 per cent of capacity.

The lignite, which is pulverized by three bowl mills, has a heating value of approximately 7300 Btu per lb as fired and contains 19 per cent moisture, about 22 per cent ash, and has an ash fusion temperature of 1980 F. Because of these fuel characteristics, as well as the grit content of the unwashed blast-furnace gas, a liberal furnace volume of over 35,000 cu ft was provided, gas passages were made wide and ample soot-blowing equipment installed. Soot hoppers were placed beneath the boiler and economizer passes and from these hoppers the accumulations are piped to the ash-sluicing system.

The furnace is completely water cooled with finned tubes on the front, side walls and roof, plain tubes at the rear and a water screen extending above the hopper bottom from which the ashes are removed by sluicing.

Tangential firing was adopted for burning these combination fuels. Each of the four burner assemblies, one to a corner, comprises three lignite, three blast-furnace gas and three coke-oven gas nozzles.

With feedwater entering the economizer at 212 F, the calculated performance indicated an overall efficiency of 79.5 per cent when burning 80 per cent blast-furnace gas and 20 per cent lignite; or 80.3 per cent efficiency when operating entirely on lignite.



Section through large steel-plant unit

A Mine-Mouth, Tunnel-Type Power Plant in China

By L. C. TAO

Kun-ming Electricity Works

Mention has been made from time to time of the tunnel-type of power plant employed in China during the war as a protection against air-raid attack. The following notes refer to one such plant of 2000-kw capacity in which protection was combined with mine-mouth location and an arrangement to effect economies in both construction and operation. Several novel features were incorporated, including gravity supply of condenser circulating water and that required for ash sluicing; also auxiliary power from a small hydro plant.

THE initial installation in this mine-mouth, tunnel-type power plant, undertaken in September 1942 and completed ready for operation in April 1943, comprised a 2000-kw condensing turbine-generator supplied with steam at 360 psi pressure 700 F by a compartmented chain-grate stoker-fired sectional-header boiler of 26,000 lb per hr rated evaporation. The equipment, weighing approximately 300 tons, together with another 300 tons of construction materials, had to be transported by human and animal power a distance of some nine miles over rough terrain, including a 1600-ft mountain.

Economies effected by tunnel construction, compared with a building, included the elimination of foundation piling as well as considerable reinforced concrete in foundations and much steelwork. Coal is taken directly to the stoker through a branch tunnel, a distance of 650 ft from the mine mouth, thus rendering fuel transportation and handling costs almost negligible. Also, the condensing water is supplied by gravity and the ashes are sluiced by the same means, which saved the initial and operating costs of pumps. These combined economies more than offset the cost of excavating the tunnel.

Dimensions of the tunnel were kept as small as possible, consistent with the space required for installation, operation and maintenance of the equipment. The main tunnel, which is approximately 23 ft wide, 136 ft long and 36 ft average height, utilizes four branch tunnels—one for the coal intake, one for the water intake, an ash outlet and a transmission line outlet. A fifth branch was excavated, leading from the middle of the main tunnel, for future use in accommodating connecting piping for contemplated extension of the plant.

The coal and the water intake tunnels, which are $6^1/_2$ by $6^1/_2$ ft in cross-section, were developed from utilization of the excavating headings, at small additional expense, with their tops in line with the top of the main tunnel. The two outlet tunnels are below the level of the operating floor. The arrangement will be apparent by reference to Fig. 1.

The walls of the tunnels are lined with common brick and have semi-circular concrete paved arches. A vertical, brick-lined shaft slightly more than 5 ft in diameter serves as a chimney.

Water Supply

A small dam was constructed to impound the water from a nearby stream and this water is made to pass through one of the inlet tunnels to supply the condenser circulating requirements, after which it is discharged under the stoker for sluicing the ashes. This arrangement not only saves the labor of ash handling, but it also avoided the necessity of excavating a boiler-room basement and the attendant columns for boiler support.

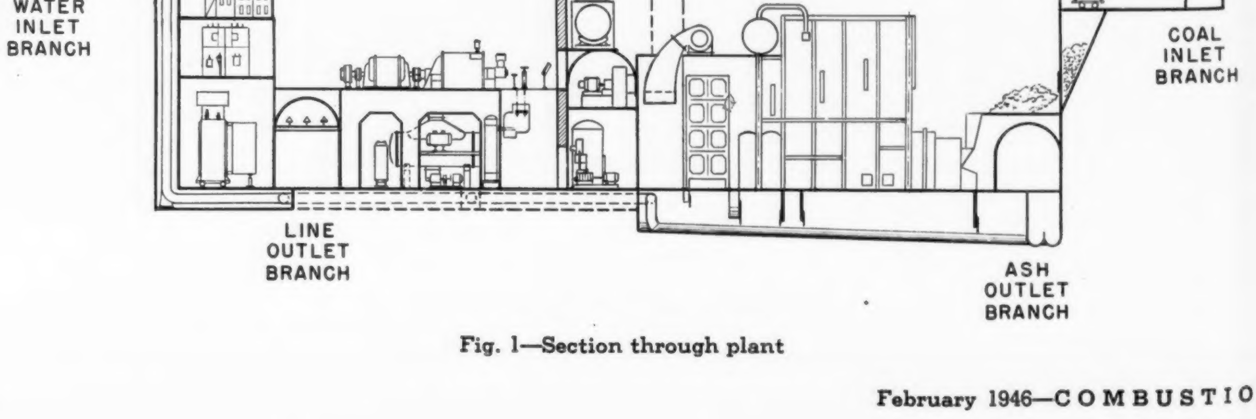


Fig. 1—Section through plant

Fig. 2—Entrance to plant, showing branch tunnels and hydro plant

Fig. 4—The condenser was handled by man power

Surplus water over that required for the condenser is utilized by a 100-kw hydroelectric set for house service. This provides power for auxiliary drives, station lighting and an independent source of energy for starting the plant, without affecting the fuel consumption, and saved the cost of installing a diesel-electric generating set or a storage battery.

A further saving in initial cost of reinforced concrete was effected by adopting cantilever beams, anchored into the rock of the tunnel side, for carrying the turbine crane. This arrangement also helped to minimize tunnel space.

Ventilation is important in a tunnel, but by arranging for the forced-draft fan to take its air at the top of the boiler, sufficient circulation of air was attained without installing a ventilating system. This had the added advantage of supplying moderately heated air from the top of the boiler to the stoker, which tended, however slight, to improve the thermal efficiency.

The relatively short time in which this plant was built is remarkable when it is considered that no contractor was employed, the labor was inexperienced, suitable tools were lacking and some of the equipment was not complete when received. However, operation is reported as entirely satisfactory.

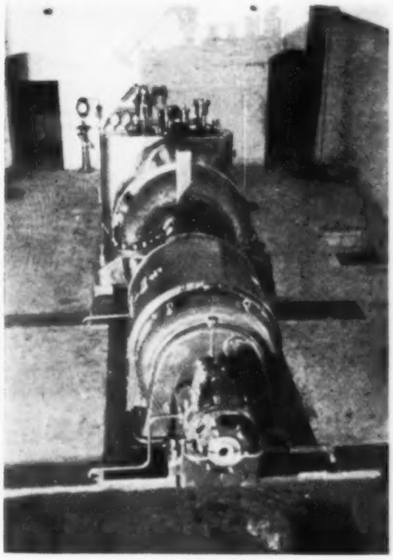


Fig. 5—View of turbine room

Fig. 3—Transportation of stoker floor beam by animal power

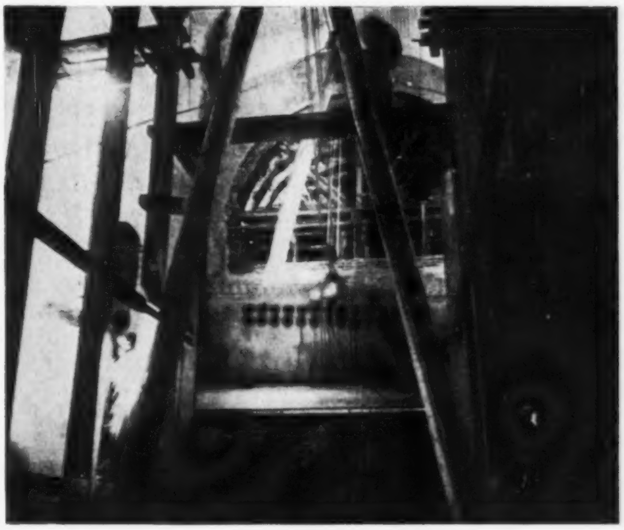


Fig. 6—The boiler drum was lifted while work on the turbine section of the plant was in progress

LA MONT BOILERS IN GREAT BRITAIN

Following closely upon the symposium on forced-circulation at the recent A.S.M.E. Annual Meeting, these two papers presented in London before the Institution of Mechanical Engineers on January 18, 1946, are of particular interest. The first, by G. A. Plummer, outlines the development of this type of steam-generating unit, discusses design features and relates operating experience with a number of the 24 units of various capacities up to 350,000 lb of steam per hour and pressures up to 1400 psi in use in England. The second paper, by Messrs. Begg, Hebblethwaite and Cooke, relates operating experience of three such units with special reference to feedwater problems. Because of space limitations, it is possible here to reproduce the papers only in extract.

Development of the La Mont Boiler

By G. A. PLUMMER*

THE La Mont forced-circulation boiler was first introduced into England in 1936, and although considerable experience was already available on the Continent (where some 150 installations then existed) the need for further development was immediately apparent, not only to bring this type of steam generator into line with British practice, but also because the installations then existing were comparatively small units operated for the most part at moderate steam pressures and temperatures.

It will be seen from the table that La Mont boilers have been installed in this country for a wide range in pressures, temperatures and capacity. Fig. 1 shows one of two low-set boilers for 60,000–75,000 lb of steam per hour at 625 psi and 914 F total steam temperature; Fig. 2 represents one of three high-offset boilers for 150,000 lb of steam per hour at 1400 psi and 960 F; and Fig. 3 shows a special duty oil-fired boiler operated for works testing up to 80,000 lb per hr at 400 psi and 700 F. These illustrations indicate the flexibility of design permitted by forced circulation.

To arrive at the most desirable size of combustion chamber, the greatest possible use must be made of radiant-heating surface, and in the case of La Mont boilers this can most readily be achieved by the provision of walls lined with closely pitched bare tubes entirely surrounding the combustion chamber; the forced circulation insuring that, even with the greatest heat transfer rendered by present methods of combustion, the tubes are adequately safeguarded against overheating.

Fig. 4 illustrates a La Mont oil-fired combustion chamber having a heat-release rate of about 335,000 Btu per cu ft and 630,000 Btu per sq ft of projected radiant-heating surface per hour. However, above a furnace rating of 290,000 Btu per cu ft evidence of incomplete combustion appeared in this unit.

Fig. 5 illustrates a La Mont stoker-fired combustion chamber in which the heat release is 27,800 Btu per cu ft per hr and 98,500 Btu per sq ft of projected radiant-heating surface per hour.

Flexibility of Operation

Because of the high circulation rate at all loads, the surface exposed to radiation, and the comparatively small water content, this type of boiler is extremely flexible in operation. Tests indicate that the rate of change in load is limited only by the flexibility of the firing equipment. For example, in the oil-fired unit shown in Fig. 3, rapid acceleration and crash-down trials were carried out in which the load was in-

* Director in charge of development and research Messrs. John Thompson, Water-Tube Boilers, Ltd., Wolverhampton, England.

LA MONT BOILERS INSTALLED IN GREAT BRITAIN

Installation	Date Installed	Number of Boilers	Capacity Nominal Evaporative Rating, Lb per Hr	Capacity Maximum Continuous Rating, Lb per Hr	Steam Pressure, psi	Steam Temperature, F	Type of Firing	Efficiency on Gross Calorific Value: Guaranteed at Equivalent Load, %	Efficiency on Gross Calorific Value: Obtained on Test, %	Use
Admiralty, "Destroyer"	1937	1	110,000	125,000	300	640	Oil	71	73.1	Naval
I.C.I. Alkali Division	1937	1	60,000	75,000	800	800	Traveling grate stoker	83.15	86.2	Works power and process
G. and J. Weir, Ltd., Glasgow	1938	1	40,000	50,000	1000	850	Chain-grate stoker	81	86.46	Electrical generation and works test
London Power Co., "Deptford West"	1939	1	280,000	350,000	375	780	Retort stoker	86.11	87.85	Central power station
Drayton Regulator Co., Ltd.	1940	1	200		600	800	Gas	...	...	Works test
I.C.I. Dyestuffs Division	1941 1944	2 1 (Rep.)	60,000	75,000	650	788	Traveling grate stokers	84	Average over 2 months, 84	Electrical generation and process steam
Admiralty	1942	5	...	80,000	400	700	Oil	...	...	Naval
I.C.I. General Chemicals Division	1942	2	60,000	75,000	625	914	Traveling grate stokers	85	Average over 1 month, 85.4	Electrical generation (Fig. 1)
Albright and Wilson, Ltd., Birmingham	1941	1	12,000	15,000	245	560	Traveling grate stoker	76	Not carried out	Electrical generation and process steam
West Midlands Joint Elec. Authority "Wolverhampton"	1942	4	120,000		400	850	Chain-grate stokers	83.2	83.4	Central power station
North Metropolitan Power Station Co., Ltd., "Taylors Lane"	1943	3	120,000	150,000	1400	960	Chain-grate stokers	87	87.83	Central power station (Fig. 2)
Power Jets, Ltd.	1944	1	80,000		400	700	Oil	...	...	Special test (Fig. 3)
Hayward-Tyler, Ltd.	1945	1	5,000		650	Sat.	Coal, hand-fired	...	...	Works test

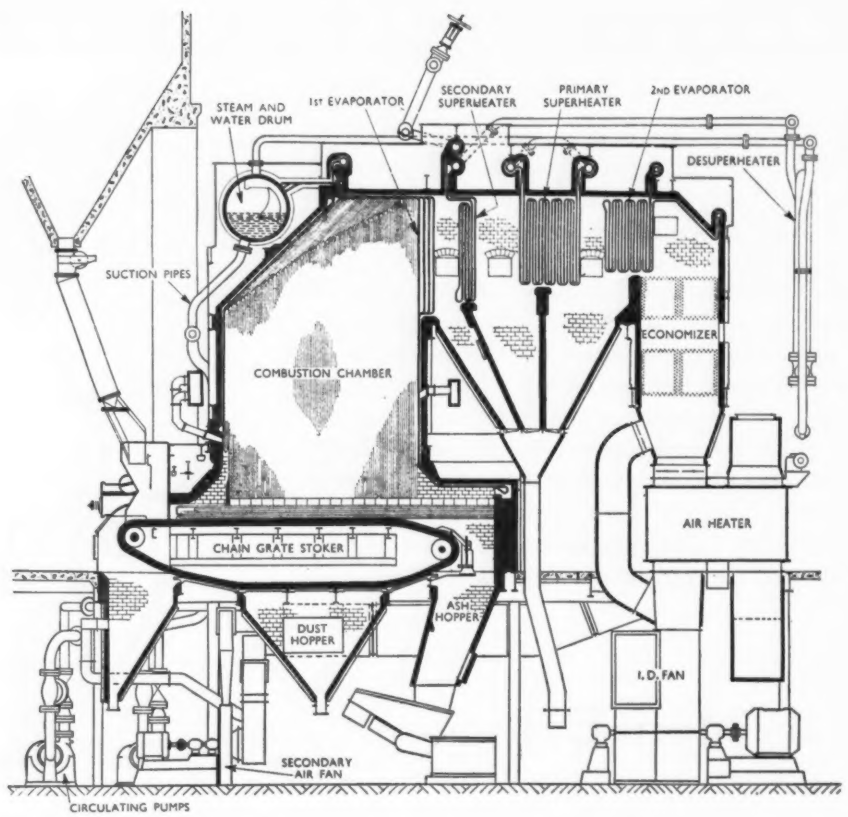


Fig. 1—La Mont boiler at I.C.I. General Chemicals Division—75,000 lb per hr evaporation, 625 psi pressure and 914 F steam temperature

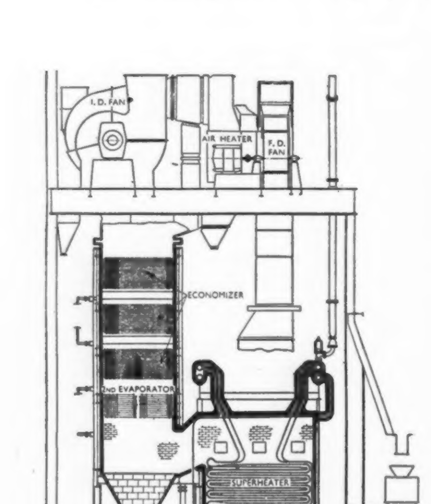


Fig. 2—One of three stoker-fired 150,000-lb per hr, 1400-psi, 960-F La Mont boilers at Taylors Lane Station of North Metropolitan Power Company

creased from zero to 70 per cent full power in 45 sec, and reduced over this range in 55 sec, without losing the water level or blowing off the safety valves. In the case of another oil-fired boiler of similar design, pressure is raised from warm condition in 5 min; the plant is then started and put on load in another 3 min, while 25 per cent increases in load are effected over a period of one minute. The plant can be shut down from full load in 60 sec. It has been found that feeding relatively cold water will affect the water level, for which reason the automatic recirculation of boiler water through the economizer is helpful.

Feedwater Requirements

Although the positive circulation provided in the La Mont design reduces the tendency toward scale formation, experience has shown that this type must be considered as a high-duty boiler and as such is sensitive to feedwater conditions, as is a boiler with natural circulation. In all cases it is advisable to aim at feedwater of zero hardness with sufficient alkalinity to protect against corrosion and with the oxygen content reduced to a minimum by deaeration. Chemical treatment, preferably external to the boiler, appears to be sufficient, with final treatment injected into the boiler circulating system.

Unusual conditions have been encountered which indicate that the forced-circulation boiler can steam satisfactorily for short periods with abnormally bad feedwater.

Very little difficulty has been experienced as a result of scale on the water side of the tubes. Where it has been experienced, satisfactory results have been obtained by the use of chemical cleaning agents, such as inhibited acid solutions; but caution is necessary to protect stainless steel if used for such parts as header nozzles. Therefore, where it is anticipated that acid cleaning may be necessary, it is advisable to use carbon steel or monel for nozzles.

The formation of sludge has proved to be one of the major difficulties resulting from excessive conditioning of feedwater within the boiler itself. Difficulty has been reported from sludge in the case of boilers returned to service after standing idle for lengthy periods. In such cases it has been found advisable to give the boiler a short period of service and then rapidly wash out all accessible parts.

In normal cases, the sludges resulting from the small amount of internal conditioning required when operating with a small percentage of chemically treated makeup, are found to be free-flowing and cause no difficulty. It is necessary, however, to insure that blowoff branches are suitably placed. These should be located in the middle of the distributor headers if the circulating pipe enters at each end; where the circulating pipe enters at one end only, the blowoff should be at the far end. With a view to reducing difficulties associated with sludge removal, and also to reduce the number of individual strainers, it is now the practice to install a small number of collective strainers of the self-cleaning type, as shown in Fig. 6.

Raising Steam Pressure From Cold

In raising steam pressure, forced circulation assures the maintenance of an even temperature throughout all parts of the boiler, and by means of the boiler-circulating pump, the economizer may be circulated with boiler water at low loads and while raising pressure. In this way boilers designed for moderate pressures and tem-

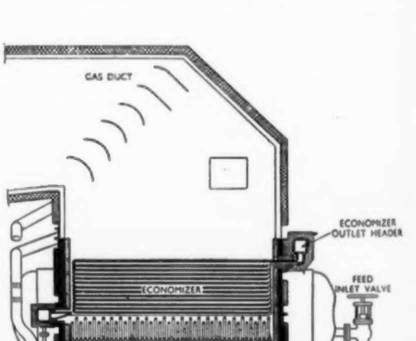


Fig. 3—An 80,000-lb per hr, 400-psi, 700-F La Mont boiler at Power Jets, Ltd.

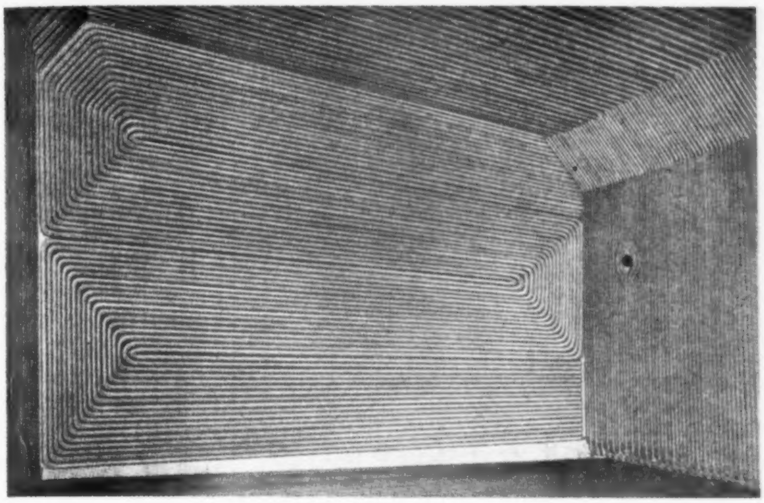


Fig. 4—Combustion chamber of oil-fired La Mont boiler

peratures may be safely brought on to the line from cold condition in 30 to 40 minutes. With high-pressure, high-temperature boilers, however, a limitation to the rate of raising pressure is the danger of overheating the superheater tubes. Therefore, it has been found necesary when first commissioning such a boiler to carry out tests to establish a safe procedure. Fig. 7 represents the results of such tests, enabling steam to be raised, from cold to full working pressure, in about four hours. To furnish further safeguards, a növel system of superheater tube cooling was provided by a supply of cooling air tapped off the secondary air supply and introduced below the primary superheater, thus tempering the gas in this zone.

In the author's experience a notable advantage accruing from forced circulation has been the facility with which clean dry steam can be obtained. This is considered to be due to the regular uninterrupted emission of steam and water evenly distributed throughout the width of the steam drum, coupled with the fact that the steam bubbles contained in the flowing steam and water mixture are of small size and are introduced above the water level.

Circulating Pumps

Considerable attention has been paid to the design of glands for the circulating pumps, as they have to be suitable for both high pressure and high temperature. Various arrangements have been adopted, including means for suitably cooling the gland assembly while leaving the gland packing to deal solely with the pressure. Typical arrangements are shown in Figs. 8 and 9.

While the former arrangement is attractive and has been applied in several cases, it has been found to have certain objections particularly when the plant operates with frequent standby periods. Under these conditions the circulating pump must be kept running, but the boiler requires little or no feedwater. Leakage of sealing water through the inner lantern ring is continuously passing into the circulating pump, and therefore into the boiler, and after a few hours it is found that the water level in the boiler has increased to an extent where blowing down is required. Also, the cooling and sealing water returned from both the inner and outer lantern rings is taken to a conservator tank, the temperature of which, during standby, will be increased by the heat carried away from the circulating pump. This rise in temperature in the conservator tank has caused difficulties.

The type of gland shown in Fig. 9 includes a cooling bush surrounding the pump sleeve, the shaft projecting through a bush which is externally cooled. The stuffing box is packed in the normal manner, provision being made for slight leakage. The amount of leakage water along the shaft is adequately cooled before it reaches the stuffing box; hence the gland packing is cooled and to some extent lubricated by the leakage water.

The gland is fitted with an extension forming an annulus around the shaft into which cold water may be passed, this being used only in emergencies when the packing has deteriorated to an extent that leakage water from the gland flashes into steam. Under these circumstances the flashed-off steam can be quenched to enable the pump to be kept running until it is possible to repack the gland. This arrangement has proved generally satisfactory, best service having been obtained from plaited graphitic asbestos packing. With pressures not exceeding 650 psi, a life of 6 to 12 months has been obtained from the packing and 3 to 5 yr from the shaft sleeves.

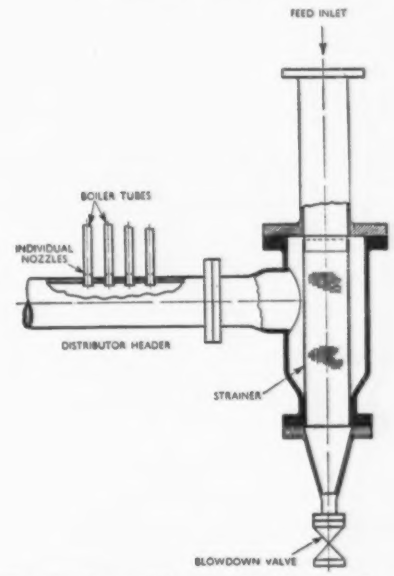


Fig. 6—Assembly of collective strainer and header

At higher pressures, the life of both packing and shaft sleeves has been considerably less.

In order to reduce gland maintenance to a minimum, it has been the practice to employ boiler circulating pumps of the single-end design, so that only one gland is required. Such arrangements have proved

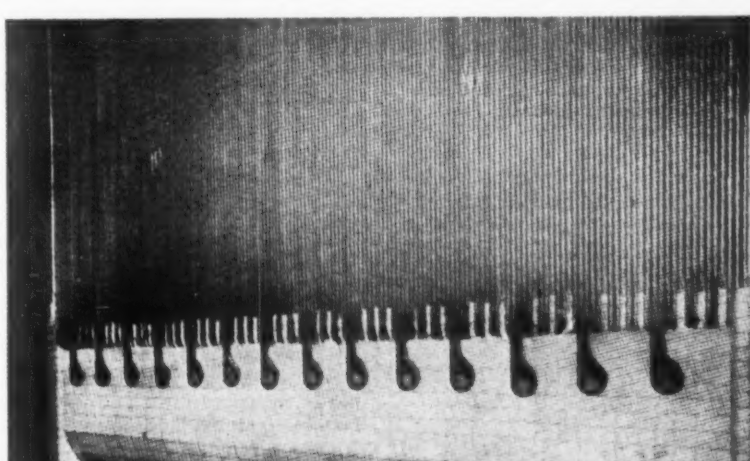


Fig. 5—Combustion chamber of stoker-fired La Mont boiler

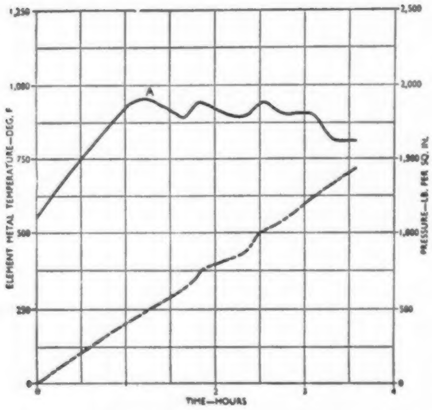


Fig. 7—Superheater metal temperature during raising of pressure, without tertiary air

quite satisfactory for pressures up to 1000 psi. At pressures above 1500 psi, however, some difficulty has been experienced as a result of end thrust resulting from the unbalanced forces applied through the pump shaft, the inner end of which is exposed to full pressure while the outer end is subject to atmospheric pressure only. Therefore, double-ended, balanced pumps, despite two glands, are probably justified for very high pressures.

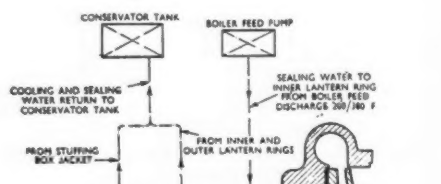


Fig. 8—Earlier arrangement of circulating-pump glands

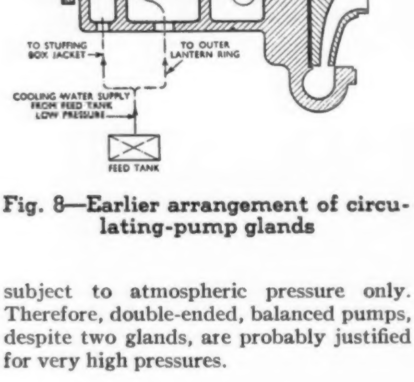


Fig. 9—Later arrangement of circulating-pump glands

A novel development which has lately been put into practice takes the form of a motor-driven circulating pump having no stuffing boxes, nor material end thrust. In this design an electric motor of the wet type and a centrifugal pump are provided with a common shaft, and together are enclosed within a common casing, as shown in Fig. 10. Its performance so far has been promising.

Economizers

Uniform distribution of feedwater through economizers has not in every case been achieved. In one highly rated unit, economizer tubes emanating from one end of a header were found to be distorted. Investigation indicated the possibility of uneven water flow, which was satisfactorily corrected by fitting throttling orifices in the tubes.

Economizer elements of bare mild steel tube loops have been frequently employed and have given very satisfactory results; they have not suffered from external corrosion, probably due to provision for recirculation. By the insertion of throttling plugs the pressure drop across the economizer is controlled. At low loads the pressure drop through the economizer is considerably reduced and enables a valve connected to the boiler-circulating pump discharge to open and circulate water through the economizer. This insures an adequate water temperature through the economizer at low loads, which not only prevents external condensation but also maintains a high temperature of the feedwater entering the boiler drum.

Tube Supports

Normally, tube elements of moderate length may be provided with the necessary stability by supports spaced between the tubes, but with long elements some additional support is required. In the early La Mont boilers, tubular members 4 to 12 in. in diameter were employed for this purpose and boiler water was circulated through them by the circulating pump. However, some difficulty was experienced with these large-diameter supports owing to inability to maintain a flow of water at sufficient velocity. Therefore, the use of large-diameter water-cooled tube supports has now been entirely superseded by forming even long tube grills in such a manner as to be self-supporting.

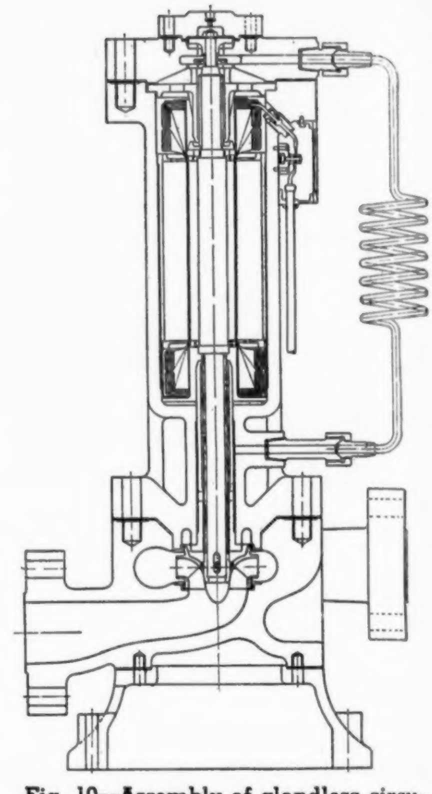


Fig. 10—Assembly of glandless circulating pump

Operating Experience with Reference to Feedwater Problems

By G. A. J. BEGG*, W. M. HEBBLETHWAITE* and G. COOKE*

THE factory concerned is a large chemical works containing three 75,000-lb per hr La Mont boilers operating at a stop valve pressure of 650 psi and 788 F steam pressure. Two were installed in 1941 and one in 1944. Each boiler unit contains an economizer, superheater, air heater, balanced draft and secondary air fans and is stoker fired. Forced circulation is provided by a motor-driven circulating pump, with a turbine-driven standby pump arranged to start automatically in case of emergency The boiler is divided into seven separate water circuits, each fed from a distribution header, with delivery either into the main drum or to a collecting header. Fig. 1 shows the boiler circulating system.

The raw-water makeup, amounting to 80 per cent, is obtained from a domestic supply with a total initial hardness of 35 ppm. It is first treated in a carbonaceous zeolite base-exchange plant where the hardness is reduced to 3 ppm maximum. The water then passes to a 12,500-gal feed tank from which it is drawn by a low-lift pump and passes through a low-pressure heat-exchanger, the heating medium being the final drain water from the blowdown flash vessel system. It is raised in temperature from 50 to 65 deg F through the heater and passes to a deaerator at 16 psi where it is raised to the equivalent saturation temperature of 252 F. Oxygen content of the feedwater is maintained at 0.01 ml per liter maximum at the deaerator outlet. A closed storage tank is located at the discharge side of the deaerator and on the suction side of the boiler feed pumps.

* I.C.I. Dyestuffs Division and I.C.I. Alkali Division.

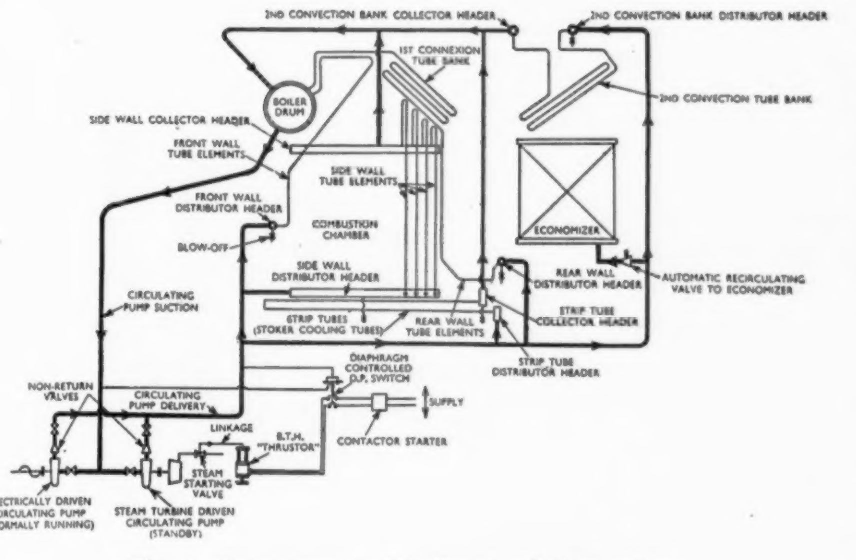


Fig. 1—Arrangement of boiler circulating system

At this point a continuous injection of sodium sulphite, "Alfloc 58" powder and caustic soda is maintained. In addition, a slug dose of "Alfloc 28" powder with a little caustic soda, to enable the powder to mix, is injected every 4 hr.

The blowdown has to be 7 to 8 per cent of the total feed in order to maintain the boiler water at the desired maximum concentration of 1600 ppm, owing to the high percentage of chemically treated feedwater. But to avoid undue waste of heat, a blowdown recovery system is installed.

Operating Experience

After continuous steaming for about 1200 hr in initial operation, the first boiler had to be taken off the load because of a tube failure in the front wall of the combustion chamber. This failure did not cause any lowering of the drum water level. Examination showed that other tubes were distorted and that the distributing headers contained considerable sludge which, at points where the damaged elements connected to the headers, was sufficient to block the strainer and orifice.

The chemical treatment had been expected to precipitate any residual hardness entering the boiler as a soft nonadherent sludge, which could be discharged in the continuous blowoff. The magnesium hardness was expected to appear as magnesium phosphate or magnesium hydroxide, the calcium being precipitated as calcium phosphate. An analysis of the sludge, however, showed that the magnesium hardness was appearing as a coprecipitate with silica, or as magnesium silicate. The calcium was appearing as calcium phosphate.

The sludge tended to precipitate in the lower portions of the boiler at points of low velocity, such as in the distributor headers, and was found to be compact. Each header is fitted with a blowoff connection but, at the time owing to lack of experience elsewhere, their regular and systematic use with the boiler on full load was felt to be unwise in view of the possibility of reversed circulation in the tube banks. Therefore, the sludge was removed by washing and boiling out under full pressure, followed by final cleaning with a solution of inhibited hydrochloric acid circulated by the boiler circulating pump.

Nevertheless, solution of the difficulty was believed to lie in the periodic removal of sludge from the distributor headers by systematic operation of the blowoff valves. Accordingly, the boiler was operated for gradually increasing periods of experimental steaming, the headers being examined at the end of each period. During each run the header blowoff valves were opened fully once per shift for two consecutive periods of five seconds each, in order to remove any accumulated sludge. Observations indicated that the sludge builds up to a maximum depth of about $^1/_2$ in., beyond which no further deposit takes place. This procedure of blowing down proved to be a complete solution to the problem and has been effective in a maximum continuous operating period of 4000 hr.

Formation of Analcite Scale

After about six months' operation the second boiler had to be taken off load due to a tube failure in an element of the first convection bank. In fact, at the time, it had operated only $47^1/_2$ hr since going on load after routine cleaning. An examination revealed two tubes in the lower portion to be split and one bend to be choked with pieces of hard white scale. Additional pieces of scale were removed from the drum.

A chemical analysis and X-ray examination showed the scale to consist of analcite, a sodium alumina-silica scale of composition $Na_2OAl_2O_34SiO_22H_2O$. A further tube failure occurred under similar circumstances in a tube element of the second convection bank about four months later.

The water supply was known to contain up to about 10 ppm of silica, but the presence of excess alumina was not suspected until further investigation showed its presence in the form of aluminum hydroxide up to 1.2 ppm (expressed as Al). The silica and alumina, together with the sodium from the exchange, had provided the materials for the analcite scale, the formation of which appeared to be quite independent of any residual hardness entering the boiler. It is very hard and strongly adherent but is capable of removal by acid cleaning.

Laboratory experiments proved that the alumina could be eliminated at the source by coagulation and filtration, but there were narrow limits of hydrogen-ion concentration (pH) in the initial dosing of the raw water for elimination of the alumina to be most effective. These limits were found to be pH values of 5.9 to 6.9. The final decision was to install additional equipment to permit filtration of the raw water.

Pending the installation of this equipment, a study was made of the formation of the analcite scale and it was found that in the second evaporator banks of the boiler a general build-up of deposits was occurring, probably due to excessive heat transfer rates in that region. Accordingly,

(*Continued on page 57*)

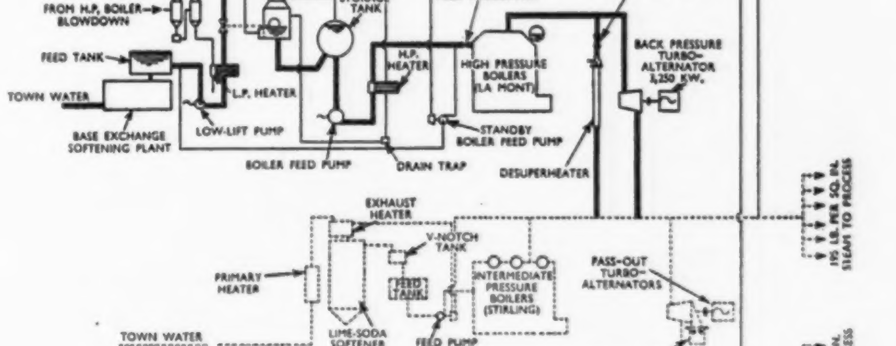


Fig. 2—Diagram of plant layout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The Gas Turbine for Locomotive Drive

An answer to the question, "Can the gas turbine burn coal successfully?" is being sought by concurrent investigations now being carried out at Johns Hopkins University, Battelle Memorial Institute and the Institute of Gas Technology, Chicago. This work is sponsored by the Locomotive Development Committee of Bituminous Coal Research, which is backed by eight railroads and a number of large coal companies. The work at Johns Hopkins has centered around the development of a new method of coal pulverization with air through an expanding nozzle, the extraction of fly ash and arrangements for applying the gas turbine to locomotive practice. That at Battelle is concerned chiefly with the problem of pressure combustion with various coals.

Speaking before the Metropolitan Section, A.S.M.E., on February 5, **J. I. Yellott,** Director of Research, Locomotive Development Committee, told of the progress of the work at Johns Hopkins, and **W. J. King** discussed the work at Battelle.

Mr. Yellott prefaced his remarks with the statement that 78 per cent of the new locomotives now on order in this country are to be diesel driven, but the fuel cost is high, amounting to 40 cents per million Btu. Railroads, as both large users and carriers of coal, have a common interest with coal producers in maintaining this market for coal, and are concerned with means for utilizing this cheaper fuel more economically than is now possible with the noncondensing steam engine. This has an overall efficiency of only about 14 per cent as compared with a calculated efficiency of 17 to 20 per cent for the gas turbine, without regeneration.

He referred to the first successful gas-turbine locomotive, built by Brown Boveri, which was placed in service on the Swiss Federal Railways in 1939, but which employs oil as fuel.

Work at Johns Hopkins

In the experimental setup at Johns Hopkins the coal is first crushed to pass through a 16-mesh screen and fed under air pressure through a small expanding nozzle in which the release of pressure produces disintegration and pulverization to the extent that 60 per cent will pass through a 200 mesh. The coarser particles are pulverized by re-cycling. A nozzle having a $^1/_8$-in. throat will pass a ton of coal per hour under suitable pressure. (This process was fully described by Mr. Yellott in his paper at the A.S.M.E. Annual Meeting last November and was reported in the December issue of COMBUSTION.)

The pulverized coal is then passed through a series of small cyclones, of a type developed by the Army for desert use with superchargers, which remove all particles greater than 5 microns. This size it is believed will not be destructive to the turbine blading inasmuch as the very fine particles will be carried along in the gas stream through the turbine and pass around obstructions.

The two factors which previously retarded development of the gas turbine, namely, an efficient compressor and metals to withstand the very high temperatures involved, have now been surmounted by perfection of the axial compressor and the availability of alloys that will stand up under temperatures up to 1350 F.

As a result, the speaker envisaged a coal-fired locomotive of 4000 hp with electric drive. Mechanical drive for such an installation might later prove feasible.

Work at Battelle

Mr. King, in discussing the work at Battelle outlined its objectives as obtaining basic data with pressure combustion and the securing of answers to problems that will arise with different types of coal. Present experiments are with a cylindrical pressure furnace, a battery of small cyclones and compressed air up to 100 psi. They have shown the inadequacy of screw feed of the coal against the combustion chamber pressure; hence a pressure-type of hopper with locks will be necessary. A vortex type of combustion chamber seems most promising.

H. D. Emmert, of Allis-Chalmers Mfg. Company, considered the critical factors to be the quantity and particle size of the ash, the gas velocity through the turbine, the gas and blade temperature, and the blade material. Erosion varies with the particle diameter and is less at high temperature. Materials now available have over twice the life of former materials employed in gas turbine work. His company limits temperature to about 1300 F and is now engaged in designing units with 25 per cent efficiency at the coupling, employing regeneration.

P. R. Sidler, of Brown Boveri, who has recently returned from Switzerland, believed that experience with pressure combustion at 35 to 40 psi in the Velox boiler would be most helpful, particularly in feeding coal to the gas turbine. Experience abroad had confirmed the desirability of employing a series of small cyclones for ash separation.

The economics of the gas turbine, for locomotive application, were summed up by **F. T. Hague,** of Westinghouse Electric Corporation, who believed that first cost must justify the better efficiency to be obtained. For this reason the open-cycle type of installation at present seems best adapted to air transport and railway use. The situation as regards stationary applications is more obscure, although one cannot safely discount the ultimate success. The high cost of materials and their machining make for high initial cost of the installation, which to be justified will necessitate use of very low-cost fuel. He mentioned that his company, in collaboration with some large boiler companies, has undertaken a study of comparisons between steam and gas turbine plants.

World Power Conference

Word comes from abroad that at a meeting of the Executive Council of the World Power Conference held in London late in November plans were initiated to hold a sectional meeting in 1947 to consider the subject of fuel economy. The place of the meeting was not decided upon, but will be determined at a subsequent meeting of the Council in Paris this spring. It will be recalled that the first World Power Conference was held at Wembley, England, in 1924, the second in Berlin in 1930, and the last meeting in 1936 at Washington. The plenary meetings were scheduled for every six years with interim sectional meetings on specific topics. The war, however, interrupted the schedule and it is anticipated that it will now be possible to resume on the regular basis.

Anthracite Organizations Consolidated

In the interest of greater efficiency and an expanded program, the activities of the Anthracite Institute and Anthracite Industries, Inc. have been consolidated into a single organization—Anthracite Institute. In the past, the former functioned mainly on matters pertaining to production, statistics and general industry matters, while the latter was responsible for research, dealer and equipment trade contacts, advertising and public relations. The research laboratory now located at Primos, Pa., will be transferred to Wilkes-Barre which will be the principal office of Anthracite Institute. The field representatives of Anthracite Industries, Inc. will continue their activities under the new arrangement.

The officers elected on January 8 are Frank W. Earnest, Jr., president; M. R. Grover, Dr. R. C. Johnson, and E. H. Walker, vice presidents; J. D. Jillson, secretary and assistant treasurer; and H. R. Stanton, treasurer and assistant secretary. Dr. Johnson will be in charge of research.

Hays Corporation Adds Cochrane Flow Meters to their Line

The Hays Corporation, Michigan City, Indiana, manufacturers of boiler room and industrial instruments and controllers, announces that, effective January 1, Cochrane Flow Meters, formerly manufactured by The Cochrane Corporation of Philadephia, became a part of the Hays line of products and will be sold by Hays representatives as Hays-Cochrane instruments for flow, liquid level, pressure and temperature measurement.

The flow meters will continue to be manufactured in Philadelphia by The Penn Industrial Instrument Corporation. Mr. Daniel Meyer and Mr. Fred Skirving, who have been associated with the instrument division of Cochrane Corporation for a number of years, have joined the Hays engineering staff at Michigan City and will specialize in flow meters and flow measuring problems.

Cleaning of Stoker-Fired Boilers

During the last few years British power plants have experienced increased trouble with deposits formed on the external surfaces of boiler, superheater and economizer tubes, also air preheaters. This is attributed to the more onerous conditions of modern boiler operation and to changes in design, as well as the characteristics of obtainable coals. The consequent falling off in availability of steam-generating units indicated that existing methods of cleaning heating surfaces were inadequate to cope with the changing conditions and a committee was formed to investigate and report on improved methods.

The work of this committee was carried on in close collaboration with power station engineers, boiler manufacturers, the Fuel Research Station and the Central Electricity Board. It was divided into two parts: (1) a subcommittee dealing with a search for ways and means in the field whereby existing difficulties might be mitigated, particularly in stoker-fired plants; and (2) a subcommittee to undertake research into the fundamental causes of these deposits and corrosion. Considerable success already has been achieved by the former, whereas the latter effort is regarded as long-term procedure.

The first subcommittee has now issued a report entitled "Methods of Cleaning Modern Stoker-Fired Boiler Plant," containing recommendations for cleaning under load or standby conditions and also under off-load conditions. It strongly advises that wherever possible boilers be taken off the line for cleaning before the total draft loss has increased 50 per cent in excess of the loss for a clean boiler; furthermore, that it is desirable to clean all heat-transfer surfaces down to the metal.

With reference to soot-blowing, under on-load and standby conditions, the report states that single-nozzle blowers for the first bank of steam-generating tubes and superheater tubes are of real value, providing they are properly adjusted and maintained, and operate with the correct steam pressure.

Water lancing of boiler tubes and superheaters[1] with jets of cold water directed onto the heating surfaces was found very effective in removing bonded deposits on both boiler and superheater tubes, it being pointed out that the essence of this process depends upon the sudden chilling of the deposits where they can be alternately chilled and permitted to heat up while the unit is in service. Such lancing is regarded as complimentary to soot-blowing for removal of the hard deposits; but water lancing may not be successful in removing the softer and more bulky deposits. However, operators are cautioned against spraying the water on supports or refractories, and particularly on expanded tube joints.

It is pointed out that one of the most effective ways of removing slag from furnace walls is a change in load conditions.

Where conditions were such that hard bonded deposits formed on economizer surfaces the committee's experience indicates that soot-blowers were ineffective except where the water temperature in the tubes was below 250 F. Prevention of such deposits could usually be achieved by washing at frequent intervals when the boiler was on standby.

To avoid deposits on air heater surfaces the minimum metal temperature should not fall below a certain critical value, depending upon the boiler conditions, fuel and general layout; usually this temperature is in the region of 160 F.

Steam Soaking

For off-load cleaning, soaking by steam or water sprays is recommended for the boiler and superheater tubes as a routine method of obtaining a high standard of cleanliness. In "steam soaking" the boiler is filled with cold water and the exterior surfaces of the tubes are subjected to a steam bath, it being important that only saturated steam be used. Where it is impracticable to use steam for this purpose a fine water spray may be employed, although this is more difficult to control. If a boiler has been allowed to accumulate very heavy bonded deposits, the process may have to be repeated several times.

Still another method under standby conditions where time is limited, is "water sluicing." This consists of washing the surfaces with water applied from a hose. It has been found effective in many cases in cleaning down to the metal.

If an economizer can be kept clean by periodic washing under standby conditions, the problem of off-load cleaning does not arise; but if heavy deposits have been allowed to form, water sluicing, steam soaking or spray soaking may be employed, the choice depending on the nature of the deposit.

In cleaning air heaters off load, it is recommended that the operation be commenced as soon as possible after the boiler has been shut down. If a soda-ash solution is used it is important to thoroughly wash away all traces of soda after treatment to avoid corrosion.

With the rotary type of air heater satisfactory off-load cleaning can best be achieved by a hot solution of soda-ash, followed by hot water applied through a nozzle at a pressure of not less than 350 psi. With tubular-type air heaters water sluicing is recommended for both the inside and the outside of the tubes. For plate-type air heaters, compressed air is recommended if the deposit is dry and loosely adherent, but if it is firmly bonded water sluicing will usually be necessary.

This report of the Boiler Availability Committee, including detailed recommendations and accounts of experience in certain stations, has been printed; but it is understood copies are available only to chief engineers of power stations in England.

[1] Although water lancing has long been practiced in this country, American engineers are not in agreement as to the advisability of employing water lancing in view of the damage that may result if precautions are not observed, especially with reference to superheaters. Many prefer steam or air for this purpose—Editor.

MIDWEST POWER CONFERENCE PROGRAM

RESUMING its annual meetings after suspension in 1945 because of wartime regulations banning conventions, the eighth Midwest Power Conference will be held at Palmer House, Chicago, April 3, 4, and 5, under the sponsorship of the Illinois Institute of Technology, with the cooperation of nine midwestern colleges and the local sections of eight engineering societies. The preliminary program as announced by Stanton E. Winston, Director of the Conference, is as follows:

Wednesday, April 3

10:15 a.m. Opening Meeting. L. E. Grinter, Chairman.

Address of Welcome by James D. Cunningham, President, Republic Flow Meters Co.

Response by T. R. Agg, Dean, Division of Engineering, Iowa State College.

"Atomic Energy," by P. W. Swain, Editor of *Power*.

"Future Requirements and Trends in the Use of Electric Power," by Howard P. Seelye, Detroit Edison Co.

12:15 p.m. Joint Luncheon with A.S.M.E. J. C. Marshall, Chairman.

Speaker: Alf Kolflat, Sargent and Lundy, Chicago. "Problems in Power Plant Design."

2:00 p.m. Central Station Practice. P. F. W. Waller, Jr., Chairman. (Sponsored and arranged by the Power and Fuels Division, Chicago Section, A.S.M.E.)

"Automatic Control of Steam Generators and Auxiliaries," by P. S. Dickey, Chief Engineer, Bailey Meter Co.

2:00 p.m. Developments in Air Conditioning.

"Centrifugal Compressors," by W. H. Carrier, Carrier Corp.

"Cooling Tower Selection," by J. Lichtenstein, Foster Wheeler Corp.

3:30 p.m. Feedwater Treatment. C. H. Fellows, Chairman.

"Problems in Water Conditioning in Plants Using High Percentages of Make-up," by Leo F. Collins, Detroit Edison Co.

3:30 p.m. Recent Electrical Developments. J. S. Gault, Chairman.

"Transmission-line Fault Locator for the Rio Negro Project," by Kenneth W. Jarvis, Consulting Engineer.

"The Use of Silicone Insulation," by G. L. Moses, Westinghouse Electric Corp.

"The Application of Rotating Regulators," by L. T. Rader, Illinois Institute of Technology.

Thursday, April 4

9:00 a.m. Parallel Operation and Interconnection. E. W. Kimbark, Chairman.

"Damper Windings for Waterwheel and Diesel Generators," by W. L. Ringland, Allis-Chalmers Manufacturing Co.

"Power Exchange in Interconnected Systems," by C. W. Mayott, Hartford Electric Light Co.

9:00 a.m. Developments in Space Heating. Ralph E. Turner, Chairman.

"Radiant Heating," by T. Napier Adlam, Sarco Co., Inc.

"Industrial Applications of the Heat Pump," by Philip Sporn, American Gas & Electric Service Corp.

10:30 a.m. Hydro Power No. 1. H. O. Croft, Chairman.

"Present Status of the Proposed Hydroelectric Development of the St. Lawrence River," by Carl Giroux, Assistant to the Chief of Engineers.

"Hydroelectric Power in the Missouri Basin," by B. H. Greene, Federal Power Commission.

12:15 p.m. Joint Luncheon with A.I.E.E. J. F. Calvert, Chairman.

Speaker: D. C. Prince, General Electric Co. "Promotional Engineering."

2:00 p.m. Insulation Problems on Power Systems. C. E. Bauman, Chairman. (Sponsored and arranged by the Power Group, Chicago Section, A.I.E.E.)

"Field Testing of Insulation," by A. L. Brownlee, Commonwealth Edison Co.

"Transients in Electric Power Systems," by H. A. Peterson, General Electric Co.

"Review of Present and Future Conditions in the Cable Field," by R. J. Wiseman, The Okonite Co.

2:00 p.m. Diesel Power. R. E. Summers, Chairman.

"Exhaust and Intake Mufflers and their Effect on Performance of Diesel Engines," by Robert W. Huddle, Burgess-Manning Co.

"Effect of Superchargers on Diesel Performance," by Ralph Miller, Nordberg Manufacturing Co.

3:30 p.m. Gas Turbines No. 1. D. L. Arm, Chairman.

"Where the Gas Turbine Stands Today," by L. N. Rowley, Managing Editor, and B. G. A. Skrotzki, Assistant Editor, *Power*.

"Linear Relationships in Gas Turbines," by John T. Rettaliata, Illinois Institute of Technology.

6:45 p.m. All Engineers Dinner, Grand Ball Room.

Speaker: Lt. Gen. Raymond A. Wheeler, Chief of Engineers, U. S. Army.

Friday, April 5

9:00 a.m. Gas Turbines No. 2. J. T. Rettaliata, Chairman.

"The Gas Turbine in Industry," by J. R. Carlson, Westinghouse Electric Corp.

9:00 a.m. Hydro Power No. 2. Ben G. Elliott, Chairman.

"Spillway Gate Operation to Prevent Erosion Below Dams," by Arno Lenz, University of Wisconsin.

"Objectives and Benefits of the Wisconsin Valley Improvement Company," by M. W. Kyler, Wisconsin Valley Improvement Co.

10:30 a.m. General Session. F. A. Faville, Chairman.

Subject: "Your Nation's Future, an Engineering Problem."

Speakers: Melvin J. Evans, Evans Associates; L. J. Fletcher, Caterpillar Tractor Co.; Samuel R. Harrell, Acme Evans Co.; A. A. Potter, Purdue University; and Roy V. Wright, Simmons-Boardman Publishing Co.

12:15 p.m. Conference Luncheon. W. A. Lewis, Chairman.

Speaker: J. A. Hutcheson, Associate Director, Westinghouse Research Laboratories. "Radar," Demonstration and Lecture.

2:00 p.m. Industrial Power Plants. H. L. Solberg, Chairman.

"Modernization of Small Power Plants," by C. M. Garland, Consulting Engineer.

"Smoke Abatement in Small Power Plants," by Carroll F. Hardy, Appalachian Coals, Inc.

"Extraction Turbines for Industrial Power," by L. E. Newman, General Electric Co.

3:45 p.m. Fuels. H. B. Dirks, Chairman.

"Coal Handling from Bunker to Stoker," by A. J. Stock, Stock Engineering Co.

"New Developments in the Coal Atomizer," by John I. Yellott, Director of Research, Locomotive Development Committee, and A. D. Singh, Institute of Gas Technology.

3:45 p.m. Industrial Load Supply. W. A. Lewis, Chairman.

"Electromagnetic Processes of the Atomic Bomb Project," by R. R. Wisner, Stone & Webster Engineering Corp.

"Electrical Power Supply for Steel Mills," by F. W. Cramer, Carnegie-Illinois Steel Corp.

"Special Problems in Industrial Power Supply," by R. L. Witzke, Westinghouse Electric Corp.

Pressure Vessel Research Begun

A comprehensive pressure vessel research program covering materials, design, fabrication, inspection and testing of unfired pressure vessels has been started by the Welding Research Council, which is sponsored by the American Welding Society, American Society of Mechanical Engineers, American Institute of Electrical Engineers and other engineering societies. This program has been initiated to answer the need for quantitative data by those engaged in pressure vessel design and construction to insure sound design and reasonable life. During the war, experimental work had fallen behind the increased use of both carbon and alloy steels in larger and more complex designs of welded vessels used in process industries under increasingly severe service conditions. The lack of factual information, has resulted in acknowledged over-conservatism in design and has hastened the start of the new research program.

The chairman of the new Pressure Vessel Research Committee is Walter Samans, who is also chairman of the A.S.M.E. Boiler Code subcommittee on unfired pressure vessels and the first meeting of the new committee was held on January 10, to sift those problems of greatest need, based on reports of defects developed in service, and to plan coordination of the new investigations with other committees and research already being conducted.

Peacetime Uses of Atomic Power

Present high cost of producing atomic or nuclear energy will rule out for the immediate future its use for automotive and railroad locomotive power, as well as a host of low power applications, C. G. Suits, Vice President and Director of Research, General Electric Co., told the Winter Convention of the American Institute of Electrical Engineers on January 25.

"Atomic power plants for electric power generation will probably at some time in the distant future, compete successfully with coal, oil and water energized plants," he declared. "In fact, this ultimate possibility is an important hedge against the ultimate exhaustion of the natural oil and coal reserves. But it should be borne in mind that there is nothing in the present status of nuclear research to justify the hope of direct conversion of nuclear to electrical energy. Hence, this competition with conventional fuel, in so far as known today, must be evaluated from a consideration of heat production as a step in the conversion cycle."

Reviewing peacetime possibilities, Dr. Suits pointed out: "With these basic facts of today, we can now consider some prospective applications of nuclear energy, that is, of chain reacting piles. The fact that they must be large immediately rules out a host of low power applications. Automotive power is out and railroad locomotive power is almost certainly out. Large ship propulsion seems not only possible, but attractive, but on a strategic rather than a competitive basis. An advantage gained in the space required for fuel is partly offset by the space required for shielding. Evidently a detailed research and engineering study will be required to evaluate this application. Perhaps large electric power plants are in the running in areas, where there is practically no conventional fuel."

Early Application Not Expected

Discussing development programs directed toward the use of nuclear energy for power production, Dr. Suits said: "Development programs directed toward the use of nuclear energy for power production should be undertaken by all branches of the power industry with governmental support, but not in the anticipation of quick application in competition with conventional fuels. A large amount of fundamental research in nuclear and related fields also will have to be done in support of the long-range program. Since much of the equipment required in nuclear research today, such as cyclotrons and betatrons, is large and expensive, it will be necessary for the government to support the fundamental program, if it is to progress at an adequate rate.

"The development of economical atomic power is not a simple extrapolation of knowledge gained during the bomb work. It is a new and difficult project and great effort will be required to reach a satisfactory answer. Needless to say, it is vital that atomic policy legislation now being considered by the Congress recognizes the essential nature of this peacetime job, and that it not only permits but

encourages the cooperative research-engineering effort of industrial, government and university laboratories for this task."

In concluding, Dr. Suits said: "Here is a vast unknown to explore. Here is an endless frontier. The goal of nuclear research is the vast storehouse of energy in the atom—10 billion kilowatt-hours per pound. Today we obtain by fission only one-thousandth of this potential. Some day we will obtain more."

TVA Output and Return

Among a mass of statistics contained in the recently issued annual report of TVA covering operations in its fiscal year ending last June, the following figures are of particular interest:

The total output from its own generating plants was 11,454,000,000 kwhr of which approximately 85 per cent represented hydro power and 15 per cent steam power, the latter produced principally by the Watts Bar steam plant which reported an average coal consumption of 0.95 lb per kwhr. This output is exclusive of that produced by eight aluminum plants operating temporarily under TVA jurisdiction. Also, considerable energy was purchased from neighboring utilities and some 468 million received under interchange agreements. Energy was distributed to 91 municipalities and 46 cooperative systems, in addition to numerous war plants. The maximum demands on the system was 1,933,000 kw.

Power revenues for the year totaled over 39 million dollars of which 18 million was net income. This represented a rate of return of 4.8 per cent on that part of the investment allocated to power.

Liquid Fuel Research

A new laboratory and research unit, where the Bureau of Mines will conduct experiments in the production of gases required in the manufacture of synthetic liquid fuel from coal, will soon be established at the University of West Virginia. Under a cooperative agreement between the Bureau and the University, the latter will initiate a research program involving about $100,000 annually. The laboratories, which will be provided by the University, will be staffed by Bureau personnel consisting of 18 to 20 technologists.

This project forms an important part of the large scale five-year synthetic liquid fuels program authorized by the 78th Congress. Since the two processes in general use for converting coal or lignite to liquid fuels both involve the use of gases, the work at the University of West Virginia is expected to hold a key position in the future development of the Bureau's program.

A.S.T.M. Meetings

The Executive Committee of the American Society for Testing Materials has confirmed an earlier decision to hold the Forty-ninth Annual Meeting of the Society in Buffalo from June 24 to 28, 1946, and in conjunction therewith to hold an exhibit of testing apparatus and related equipment.

The Spring Meeting of the Society will be held in Pittsburgh during the week of February 25 to March 1. Many meetings of the technical committees will take place at this time.

Personals

T. C. Westcott has been elected president of Ebasco Services, Inc. He has been associated with Electric Bond & Share Company and its subsidiaries in various engineering and administrative capacities for the past 35 years.

Melvin C. Shaw has been advanced from chief engineer to manager of the Blower and Compressor Department of Allis-Chalmers Mfg. Company with which company he has been connected since graduation from the University of Washington in 1914.

W. A. Shoudy has lately joined the Charles H. Tompkins Company, construction engineers of Washington, D. C., as mechanical engineer, and will give his attention to the new government heating plant now under construction in that city.

W. F. Jetter, formerly assistant to the president of The Air Preheater Corporation, has been elected vice president of that company.

Obituaries

Norman G. Reinicker, vice president and general manager of the Pennsylvania Power & Light Company, Allentown, Pa., died on January 13 after an illness of nearly six months. Mr. Reinicker had been associated with the company since 1920, prior to which he had served in various engineering capacities with the Detroit Edison Company and the New York Edison Company. He was 56 years of age at the time of his death.

Roger DeWolf, president of the DeWolf Furnace Corp., long associated with the Rochester Gas & Electric Corp., at one time chairman of the Prime Movers Committee of the Edison Electric Institute, and a past president of the National District Heating Association, died in Rochester, N. Y., on February 2 at the age of 66.

Joseph Putnam, well-known engineer in the electric railway field in the early 1900's and later identified with hydro power construction at Niagara Falls, died at New Rochelle, N. Y., on January 22 at the age of 75. During World War II he had been engaged in the installation of power equipment in the synthetic rubber plant at Lake Charles, La., and for a short period before his death was associated with Combustion Engineering Company.

R. W. Retterer, superintendent of equipment for the Big Four Division of the New York Central System, died on January 4 at his home in Indianapolis at the age of 57. He had been with the New York Central since 1904.

Frank F. Fowle, well-known consulting electrical engineer of Chicago, died of a heart attack at his home in Winnetka, Ill. on January 21 at the age of 68.

Business Notes

On January 1 the name of The Edward Valve & Manufacturing Company, East Chicago, Indiana, was changed to Edward Valves, Inc.

The Dampney Company of America, Hyde Park, Boston, has acquired the Thurmalox Company of Doylestown, Pa., manufacturer of "Thur-Ma-Lox" No. 7 black and No. 10 aluminum for coating dry hot surfaces up to 1600 F and 1200 F, respectively. The Company also announces the appointment of Lachlan W. MacLean as manager of its Boston Sales Office.

Combustion Engineering Company, Inc., New York, has appointed The Constructor Company, 786 Eustis St., St. Paul, Minn., as its sales agent for the states of Minnesota, North Dakota, South Dakota and bordering territory in Wisconsin and Iowa.

"Operating Experience with Reference to Feedwater Problems"—*Continued from page 49.*

the water circulation rate to these banks was increased by enlarging the nozzles to the tube elements, and experience to date indicates that this has prevented any excessive concentration of boiler water salts in the second evaporator bank. However, until the removal of alumina in the raw water is carried out, danger of formations of this type of scale will be present.

Some difficulty was experienced in the early period of operation due to secondary combustion and insufficient turbulence in the furnace, but this was corrected by the installation of over-fire jets for secondary air. Also, during this period serious fouling of the air heaters was experienced. Subsequent redesign of the soot blowers and increase in blowing pressure from 200 to 400–450 psi confined the fouling to the cold end elements, which are removable for washing.

Steam Contamination

Early doubts regarding the possibility of steam contamination arising from the use of 80 per cent chemically treated water have not materialized in practice, and the solids content of the steam, as measured by continuous conductivity recorders, never exceeds 2 ppm and is usually less than 1 ppm.

Boiler Availability and Efficiency

The longest continuous period of operation without examination of the water side of the boiler has been over 4000 hr at an average output of 70,000 lb per hr, or close to maximum capacity.

Although, due to war conditions, an official trial was not carried out, normal operating records indicate an average running efficiency of about 82 per cent.

In conclusion, in the opinion of the authors, the choice of the La Mont type as against the natural-circulation boiler, has been fully justified. The boilers are very flexible in operation and quick steamers; the circulating pumps have not caused any forced shut-down; and there is no evidence to show that by the choice of natural-circulation boilers any of the difficulties described could have been avoided.


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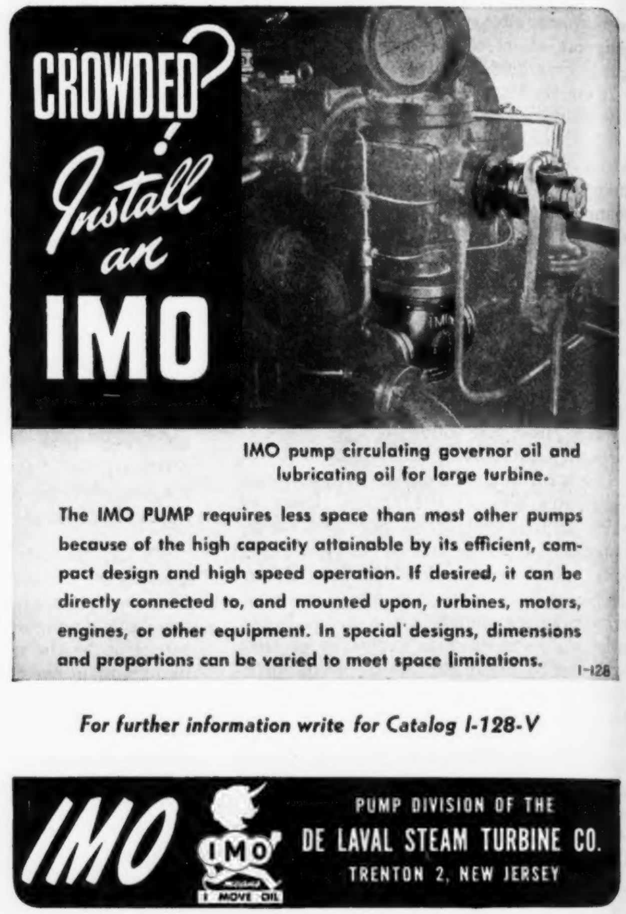
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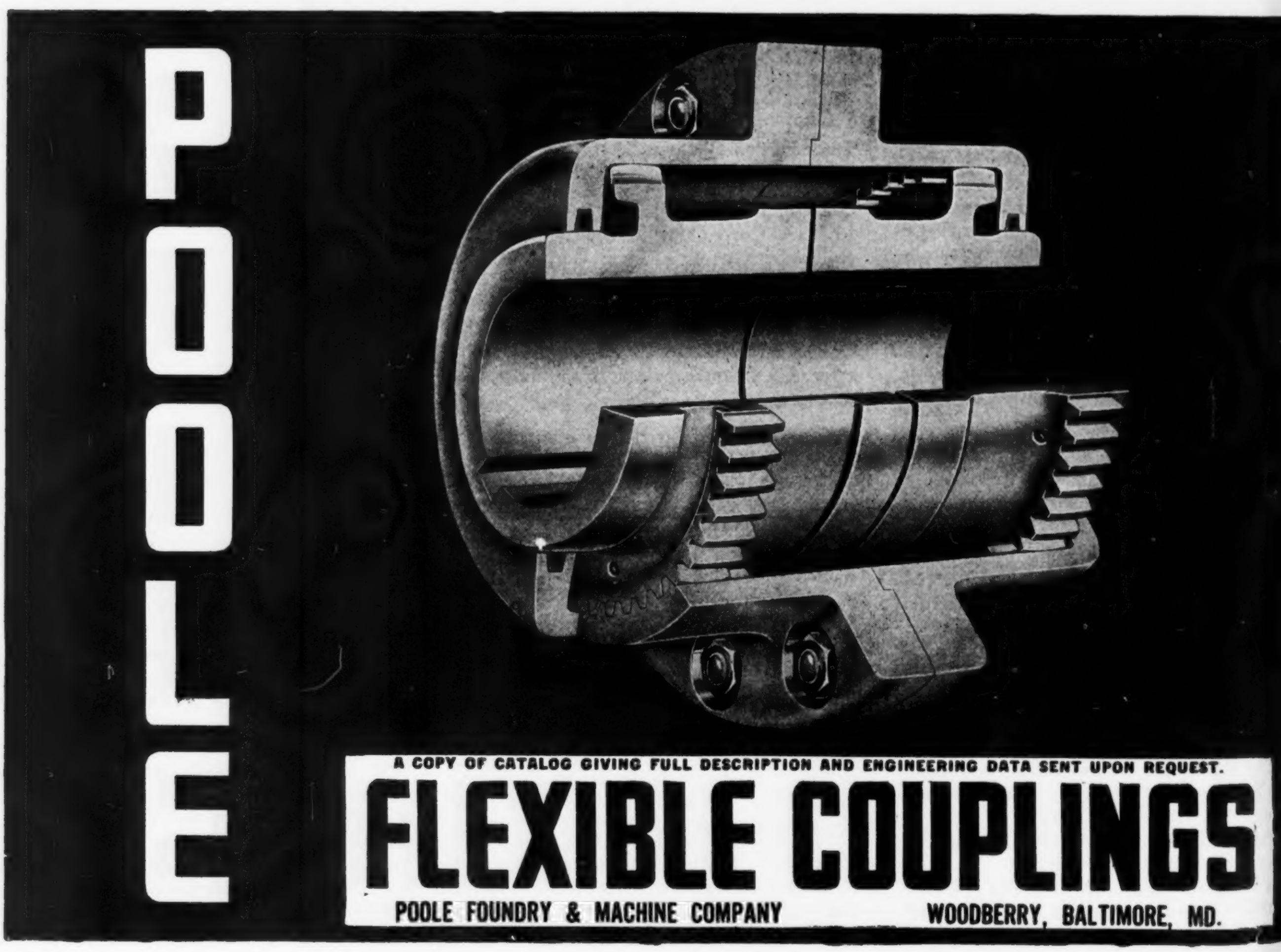
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